AD-A167 457 EAST COAST TACTICAL AIRCREW COMBAT TRAINING SYSTEM FACILITY EXPANSION CON..(U) NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON DC CHESAPEAKE.. 1/2

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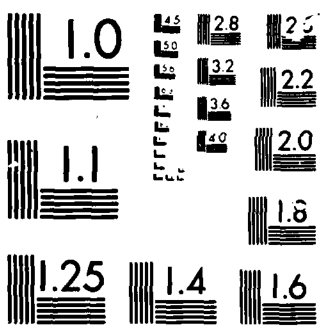


MICROCOP

CHART

DEPARTMENT OF THE NAVY
CHESAPEAKE DIV NAVFACENGCOM



# EAST COAST TACTICAL AIRCREW COMBAT TRAINING SYSTEM FACILITY EXPANSION CONCEPT STUDY



## Ocean Engineering

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD
WASHINGTON, DC 20374

(1)





# EAST COAST TACTICAL AIRCREW COMBAT TRAINING SYSTEM FACILITY EXPANSION CONCEPT STUDY

BY
T. J. O'BOYLE



FPO-1-81 (26)
SEPTEMBER 1981



OCEAN ENGINEERING
AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON,D.C. 20374

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SECURITY CLASSIFICATION OF THIS PAGE

AD-A167457

REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION<br>Unclassified | 1b. RESTRICTIVE MARKINGS |
| 2a. SECURITY CLASSIFICATION AUTHORITY | 3. DISTRIBUTION AVAILABILITY OF REP.<br>Approved for public release;<br>distribution is unlimited |
| 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER<br>FPO-1-81(26) | 5. MONITORING ORGANIZATION REPORT # |
| 6a. NAME OF PERFORM. ORG. 6b. OFFICE SYM<br>Ocean Engineering<br>& Construction<br>Project Office<br>CHESNAVFACENGCOM | 7a. NAME OF MONITORING ORGANIZATION |
| 6c. ADDRESS (City, State, and Zip Code)<br>BLDG. 212, Washington Navy Yard<br>Washington, D.C. 20374-2121 | 7b. ADDRESS (City, State, and Zip ) |
| 8a. NAME OF FUNDING ORG. 8b. OFFICE SYM | 9. PROCUREMENT INSTRUMENT INDENT # |
| 8c. ADDRESS (City, State & Zip) | 10. SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT # PROJECT # TASK # WORK UNIT ACCESS # |

11. TITLE (Including Security Classification)
East Coast Tactical Aircrew Combat Training System Facility Expansion Concept Study

12. PERSONAL AUTHOR(S)
T.J. O'Boyle

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REP. (YYMMDD) | 15. PAGES |
|---|---|---|---|
| | FROM TO | 81-9 | 110 |

16. SUPPLEMENTARY NOTATION

| 17. COSATI CODES | | | 18. SUBJECT TERMS (Continue on reverse if nec.) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | TACTS, East Coast Tactical Aircrew Combat Training System |


19. ABSTRACT (Continue on reverse if necessary & identify by block number)
This brief study was performed as per the request of the naval Air Systems Command. This report presents the results of a facility concept study and preliminary cost estimates for the future expansion of the East Coast Tactical Aircrew Combat Training System (TACTS). The present TACTS is located (Con't)


| | |
|---|---|
| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT<br>SAME AS RPT. | 21. ABSTRACT SECURITY CLASSIFICATION |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Jacqueline B. Riley | 22b. TELEPHONE 22c. OFFICE SYMBOL<br>202-433-3881 |

DD FORM 1473, 84MAR SECURITY CLASSIFICATION OF THIS PAGE

BLOCK 19 (Con't)

approximately 30 miles east of Kitty Hawk, North Carolina, and consists of four template type towers. These towers are in 81 ft., 93 ft., and two towers in 105 ft. of water. The direction of the proposed expansion is unknown therefore, the exact water depths at each new remote location is uncertain. These water depths could range from 150 ft. to 6000 ft. depending on the direction of expansion. Each proposed expansion would require as many as three new remote structures and would use the existing TACTS towers as the master stations for these remotes. The study considered vertical extensions to the existing towers to facilitate required line of sight microwave data transmission to and from range expansion units. Expansion areas considered resulted in conceptualizing structures for shallow and deep water conditions.

EAST COAST TACTICAL AIR CREW
COMBAT TRAINING SYSTEM
FACILITY EXPANSION STUDY

SEPTEMBER 1981

T. J. O'BOYLE

Approved: S. C. Ling, Director
Engineering Analysis
Division

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, DC 20374

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# 1.0 INTRODUCTION

## 1.1 Scope of Report

This brief study was performed as per the request of the Naval Air Systems Command. This report presents the results of a facility concept study and preliminary cost estimates for the future expansion of the East Coast Tactical Aircrew Combat Training System (TACTS)*. The present TACTS is located approximately 30 miles east of Kitty Hawk, N.C., ~~North Carolina,~~ and consists of four template type towers. These towers are in 81 ft., 93 ft., and two towers in 105 ft. of water. (see Figure 1.0-1). The direction of the proposed expansion is unknown therefore, the exact water depths at each new remote location is uncertain. These water depths could range from 150 ft. to 6000 ft. depending on the direction of expansion. Each proposed expansion would require as many as three new remote structures and would use the existing TACTS towers as the master stations for these remotes. The study considered vertical extensions to the existing towers to facilitate required line of sight microwave data transmission to and from range expansion units. Expansion areas considered resulted in conceptualizing structures for shallow and deep water conditions.

## 1.2 Criteria

### 1.2.1 Environmental

For this study, it was assumed the environment in the proposed range expansion areas would be similar to the criteria used for the design of the existing TACTS Towers. Some modifications to these criteria were made for the different water depths. A

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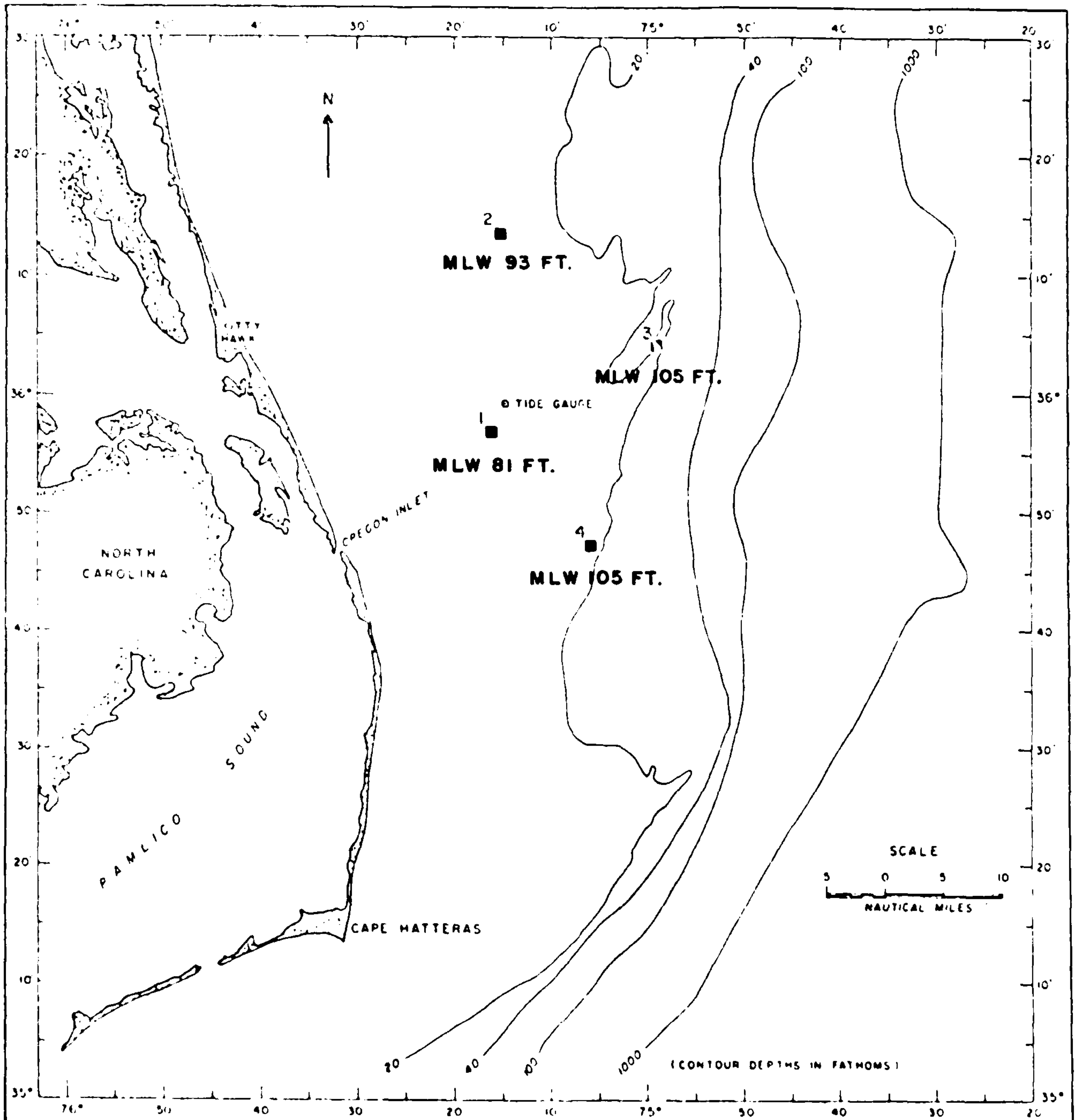
*Formerly named East Coast Air Combat Maneuvering Range (EC/ACMR)

Figure I-1 Index Map Showing Approximate Location of TACTS Towers




| Structure No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Distance to Shore (Nau. Miles) | 16.0 | 23.5 | 31.5 | 20.0 |

listing of the assumed environment used in the analysis of the guy wire tower concept and the spar buoy concept can be found in Sections 3.3 and 4.2.1, respectively, of this report.

### 1.2.2 Expected Life

It was assumed that the structures would be designed for a 20 year life.

### 1.2.3 Antenna Excursion and Rotation

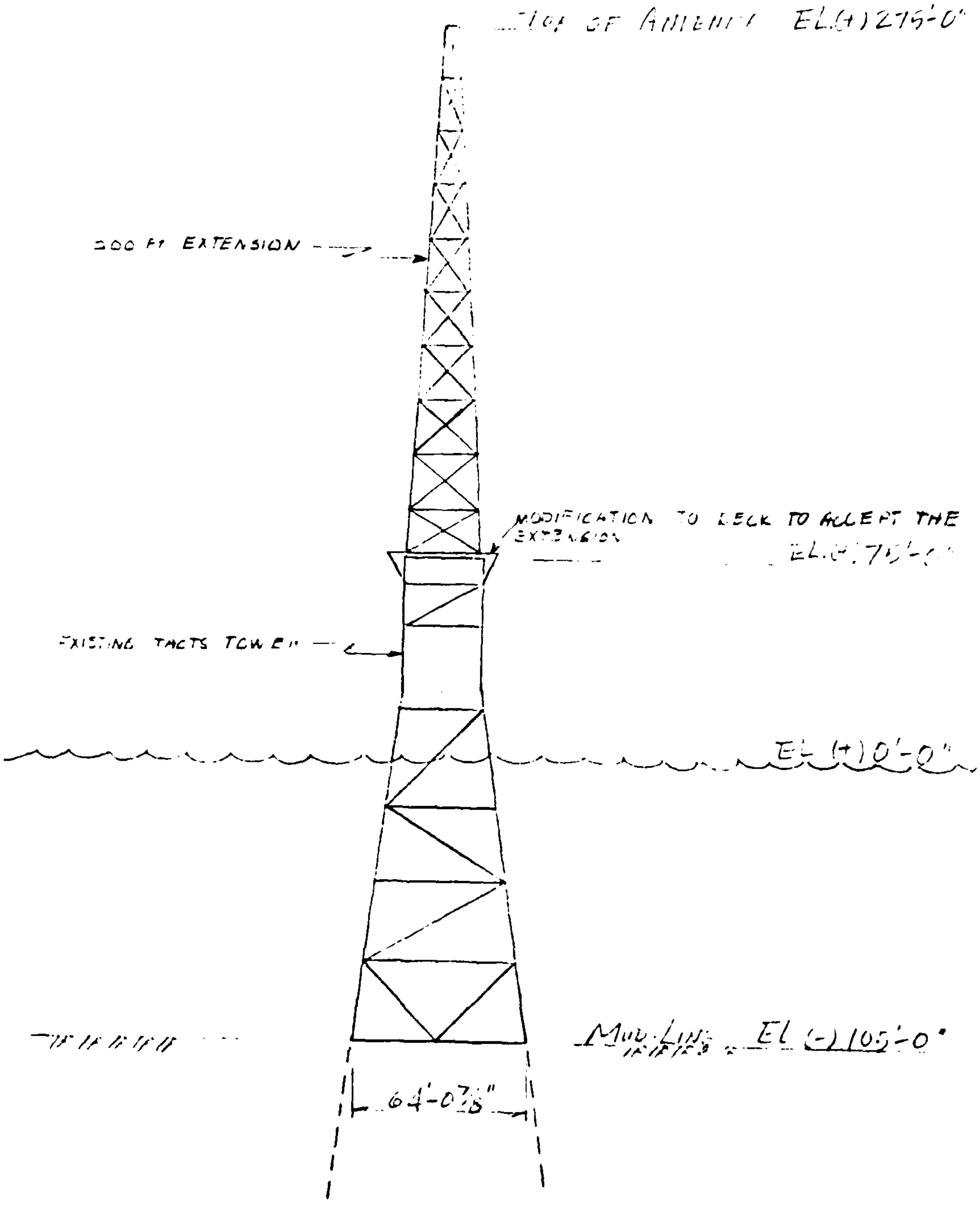
NAVAIRSYSCOM indicated that the horizontal excursion of the floating structures would not be of concern because it would be possible to track and locate each structure. The limiting factor in the amount of antenna rotation (pitch and yaw) that can be tolerated is the antenna beam width. For this report it was assumed that the antenna rotation would be limited to approximately $\pm 10^{\circ}$.

## 1.3 Concepts

### 1.3.1 200 ft. Tower Extension

The use of some of the existing towers as the master for the proposed TACTS expansion necessitates the fabrication and installation of an extension to the structures. Because the TACTS range uses microwave transmission to relay the data from the remote stations to the master, the receiving antenna on the master must be at a high enough elevation to allow line of sight operation with the remotes. Adding a 200 ft. extension to the deck of the existing TACTS tower, to be used as the master, raises the antenna to an elevation of 275 ft. above the water, (see Figure 1.0-2), and keeping the antennas on the new remotes 75 feet above the water surface results in an approximate line-of-sight separation distance of 26 NM.

FIGURE [illegible] 200 [illegible]



TOP OF ANTENNA EL(+)275'-0"
200 FT EXTENSION
MODIFICATION TO DECK TO ACCEPT THE EXTENSION
EL(+)75'-0"
EXISTING TACTS TOWER
EL (+)0'-0"
MUD LINE EL(-)105'-0"
64'-0⅞"

### 1.3.2 Shallow Water Range Expansion

For water depths less than 200 ft., either a floating or fixed structure could be used. The floating type would have to be one with relatively shallow draft, similar to a semi-submersible. The fixed structure could be either a template structure like the original TACTS towers or a guy wire tower. The guy wire tower concept was considered to be feasible. This study concentrated on the guy wire type of shallow water structure because of this task's short time frame and as stated above, the existing TACTS towers are of the template type.

### 1.3.3 Deep Water Range Expansion Structure

For the areas where the water depths can reach 4000 to over 6000 ft., the only viable remote structure would be of the anchored/floating type. There is no evidence that any unmanned, floating structure with these operational criteria has ever been moored in these water depths for an extended period of time. Therefore, there is no way to place a risk factor on this concept but the risk cannot be ignored. Two possible types of floating structure designs are the semi-submersible and the spar buoy. Either type may perform equally well and conform to the operational criteria, however, the spar buoy was the concept investigated in this report.

# 2.0 THE 200 FOOT EXTENSION CONCEPT

## 2.1 Stability of TACTS Towers With the 200 Foot Extension

The construction and installation of the four offshore towers of the Tactical Aircrew Combat Training System (TACTS) was completed in August 1977. The location of

the towers and two of the proposed expansion areas are depicted in Figure 2.0-1. Four years of operational experience have revealed over water data transmission problems in the existing tracking system which made it necessary to consider an engineering change to the original towers. The suggested solution to these problems is addressed in reference (1), and this solution was to put a 100 ft. extension on the structures. However; these extensions were never installed. The stability calculations for the now proposed 200 ft. extension, presented in Appendix A of the report, are an adaptation of the work done in references (1) and (2). The factors of safety from these calculations are presented in Table 2.0-1. The factor of safety for compression failure is relatively low for the deeper water depths but this is for a short term loading and is felt to be adequate.

TABLE 2.0-1

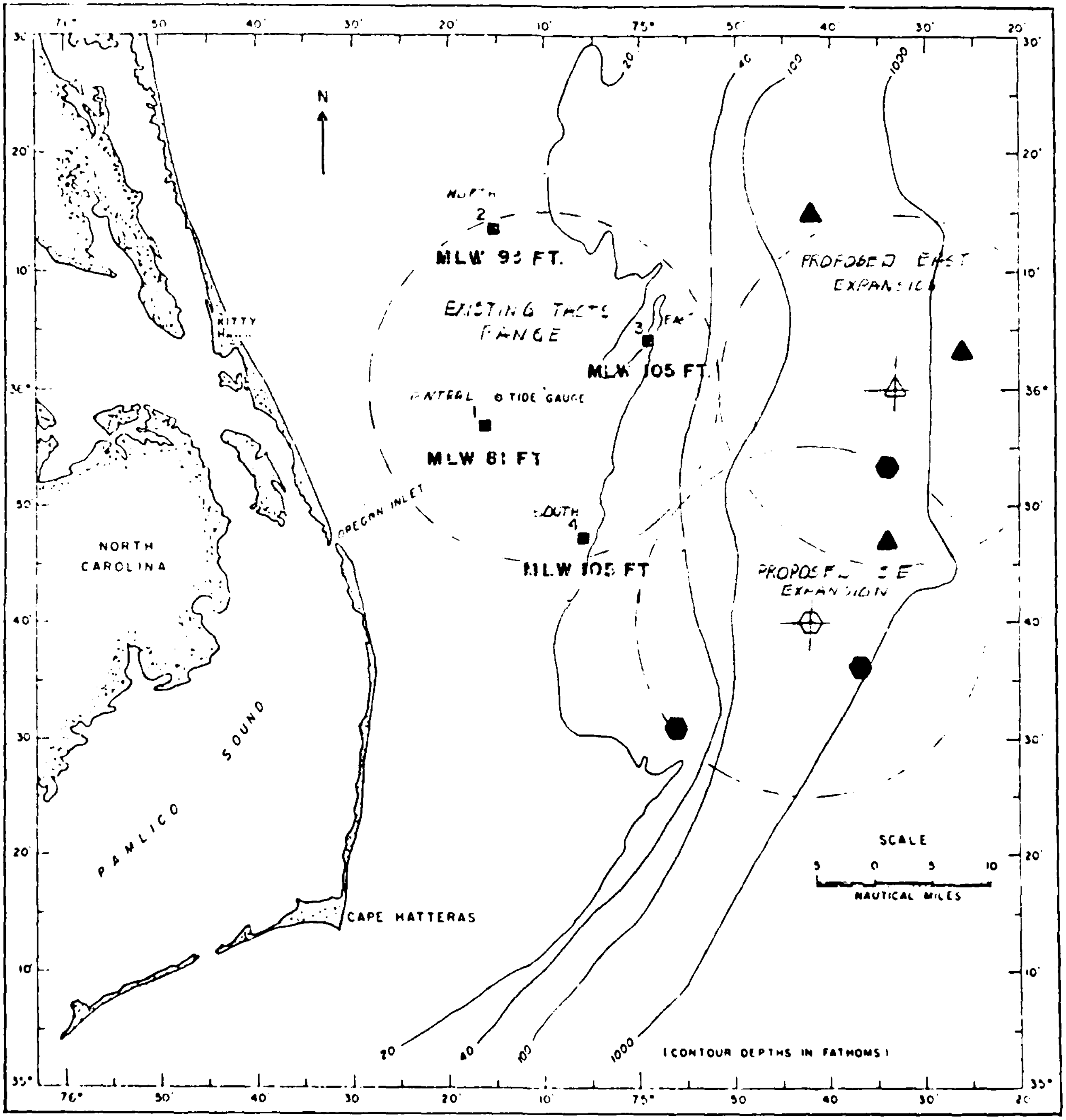
Stability of TACTS Offshore Towers with 200 foot Antenna Extension:

| TACTS Offshore Tower | Water Depth | Factor of Safety for Pile Foundation | |
|---|---|---|---|
| | | Tension Failure | Compression Failure |
| 1 | 81 feet | 1.61 | 1.42 |
| 2 | 93 feet | 1.44 | 1.20 |
| 3&4 | 105 feet | 1.41 | 1.19 |

## 2.2 Preliminary Cost Estimate

Reference (1) had indicated the 100 foot extension could be preassembled on shore in sections and transported to the erection site by helicopter. This procedure would not be possible for the 200 ft. extension because the weight of each section could exceed the lift capacity of the helicopter. Also, the top deck of the TACTS Towers would have to be modified to accept the stand alone 200 ft., extension and an additional walk-way

FIGURE [illegible] LOCATION OF THE PROPOSED EXPANSIONS



be placed around the perimeter. This tower modification would be a separate installation and could be preassembled and brought out on a barge then raised into place by a crane and welded on. Table 2.0-2 presents a preliminary cost estimate summary. A detailed breakdown of this cost estimate appears in Appendix A.

TABLE 2.0-2

Preliminary Cost Estimate for the 200 foot Antenna Extension:

| | |
|---|---|
| Material | $124,500 |
| Labor | 126,160 |
| Installation | |
| Platform Mod | 67,800 |
| Tower Extension | 173,550 |
| | $492,010 |
| A&E Platform Mod & Tower Design 10% Above | $ 49,200 |
| SIOH 10% Above | 49,200 |
| | $590,410 |
| TOTAL (9/81 Present $) | $600,000 |

NOTE: Does Not Include Antenna Cost

## 3.0 SHALLOW WATER RANGE EXPANSION CONCEPT

### 3.1 Floating Structure Concept

As stated earlier in this report, a floating structure would have to be designed as a semi-submersible because a shallow water depth requires a structure with a small draft. A spar type structure requires a much greater draft and may come dangerously

close to the sea bottom during a storm. The concept of using a floating structure in shallow water was not addressed in this study.

### 3.2 Fixed (Template) Structure Concept

This concept uses the same type of structure in the shallow water areas as used in the original TACTS range. During a phone conversation with Tera, Inc., on 1 September 1981, it was indicated that a jacketed structure for shallow (150') water may cost $5M each. This was a very rough cost and would be for an existing used structure that would be bought as is. There would be no design, fabrication, or construction control. These structures would be transported to the site, off loaded into place, and piles driven through the jacket to hold it in place. This may be a good concept if the funding is available and the schedule is such that the structures are needed quickly.

### 3.3 Guy Wire Tower Concept

This concept places a slender tower in the ocean and holds it upright with mooring lines that are under tension. The guy wire tower was modeled as a cylindrical pile, Pinned at the sea floor and held rigid at the point where the mooring lines are attached. The survival environment assumed was as follows:

| | |
|---|---|
| Water Depth | 100, 150 amd 200 ft. |
| Wave Height | 61.3 ft. |
| Wave Period | 13.6 sec. |
| Astronomical Tide | 4.4 ft. |
| Storm Tide | 3.3 ft. |
| Surface Current | 4.7 ft./sec. |

The wave force distribution for these water depths on a 24 inch and 36 inch diameter column were calculated. The results of these calculations can be found in Appendix B. The wind area above the work platform was calculated assuming there would be the same assemblage of material as found on the TACTS towers at present. For this report, the wave forces were placed on a 36 inch diameter pile in 100 feet of water to determine the horizontal force the anchors would have to overcome. Also, this horizontal force was needed to do a preliminary design of a mooring system. This concept uses a three legged chain mooring. It is important to note that no analysis of the antenna movements was performed and this may not be the final mooring configuration and may indeed contain many more legs. The total horizontal force and mooring calculations can be found in Appendix B. Based on the above concept assumptions, a summary of the preliminary cost estimate can be found in Table 3.0-1.

TABLE 3.0-1

Preliminary Cost Estimate for the Guy Wire Tower Concept:

| | |
|---|---|
| Site Survey | $ 50,000 |
| Material, Construction Tower, Stake Pile Anchor, New Chain | 517,000 |
| Installation (25 Days) | |
| Equipment | 537,700 |
| Labor | 111,700 |
| | 1,166,900 |
| A&E Design 6% Above Except Site Survey | 70,000 |
| SIOH 10% Above | 116,000 |
| TOTAL (Present $) | $1,403,600 |

NOTE: Does Not Include Post Installation Inspection

# 4.0 DEEP WATER RANGE EXPANSION CONCEPT

## 4.1 Semi-Submersible Concept

This report does not evaluate the semi-submersible concept. It was felt that the short time allotted for analysis of the deep water areas would be best spent on the spar buoy concept. Furthermore; Alan C. McClure Associates, Inc., investigated the semi-submersible (see Figure 4.0-1), and reported their findings to NAVAIRSYSCOM. There was no time to look over their concept to see if ti conformed with the operational criteria or if their proposed mooring system was strong enough to withstand the environmental loads (see Figure 4.0-2).

## 4.2 Spar Buoy Concept

### 4.2.1 Stability Analysis

The preliminary concept shown in Figure 4.0-3 was analyzed under the environmental operational conditions listed below:

| | |
|---|---|
| Water Depth | 6000 ft. |
| Wave Height | 40 ft. |
| Wave Period | 13.6 sec. |
| Surface Current | 4.3 ft./sec. |
| Bottom Current | 1.3 ft./sec. |
| Wind Speed | 60 mph. |

FIGURE 4.0-1 SEMI-SUBMERSIBLE CONCEPT

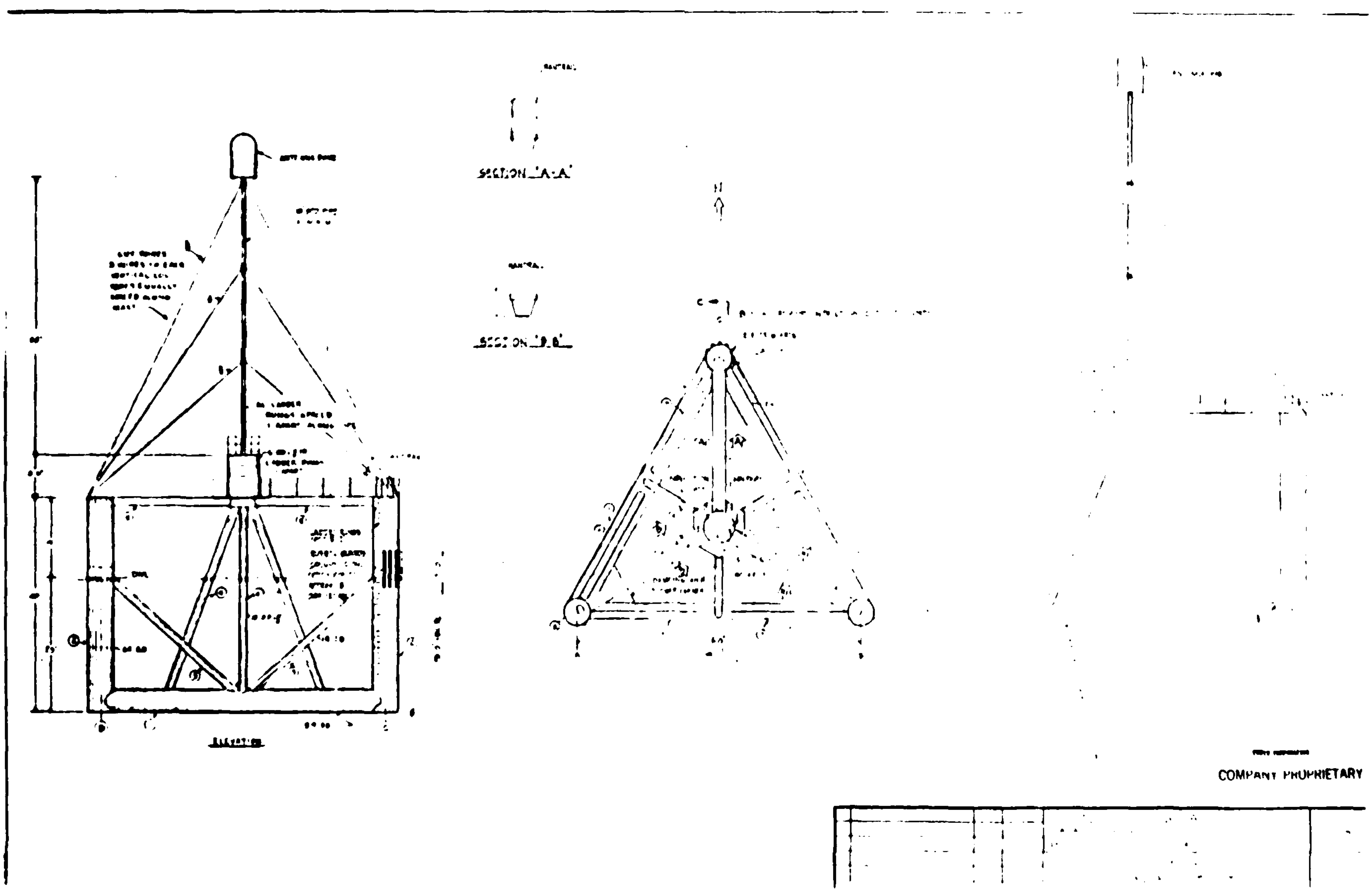


FIGURE 4.0-2 SEMI - SUBMERSIBLE MOORING CONCEPT

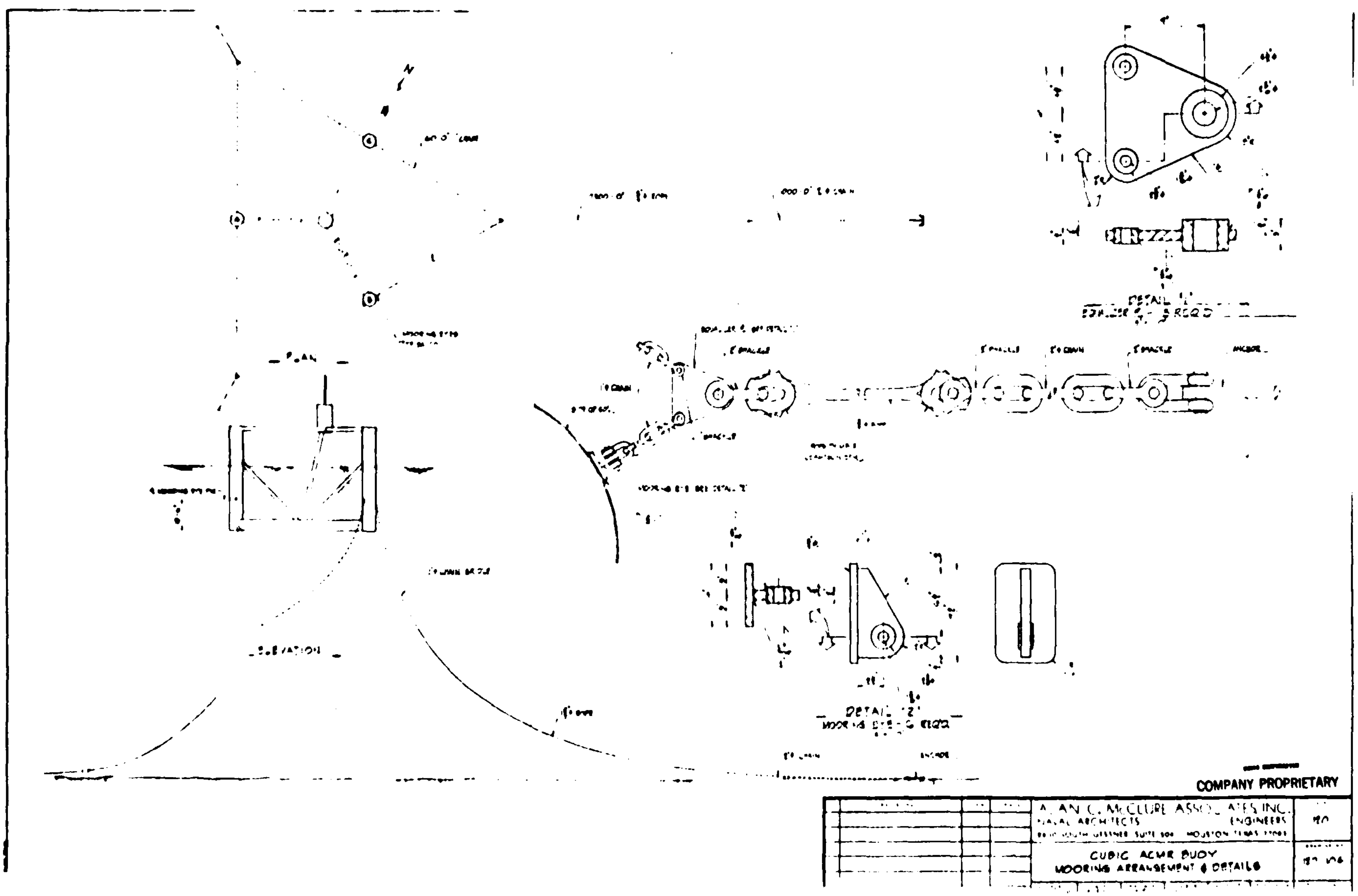
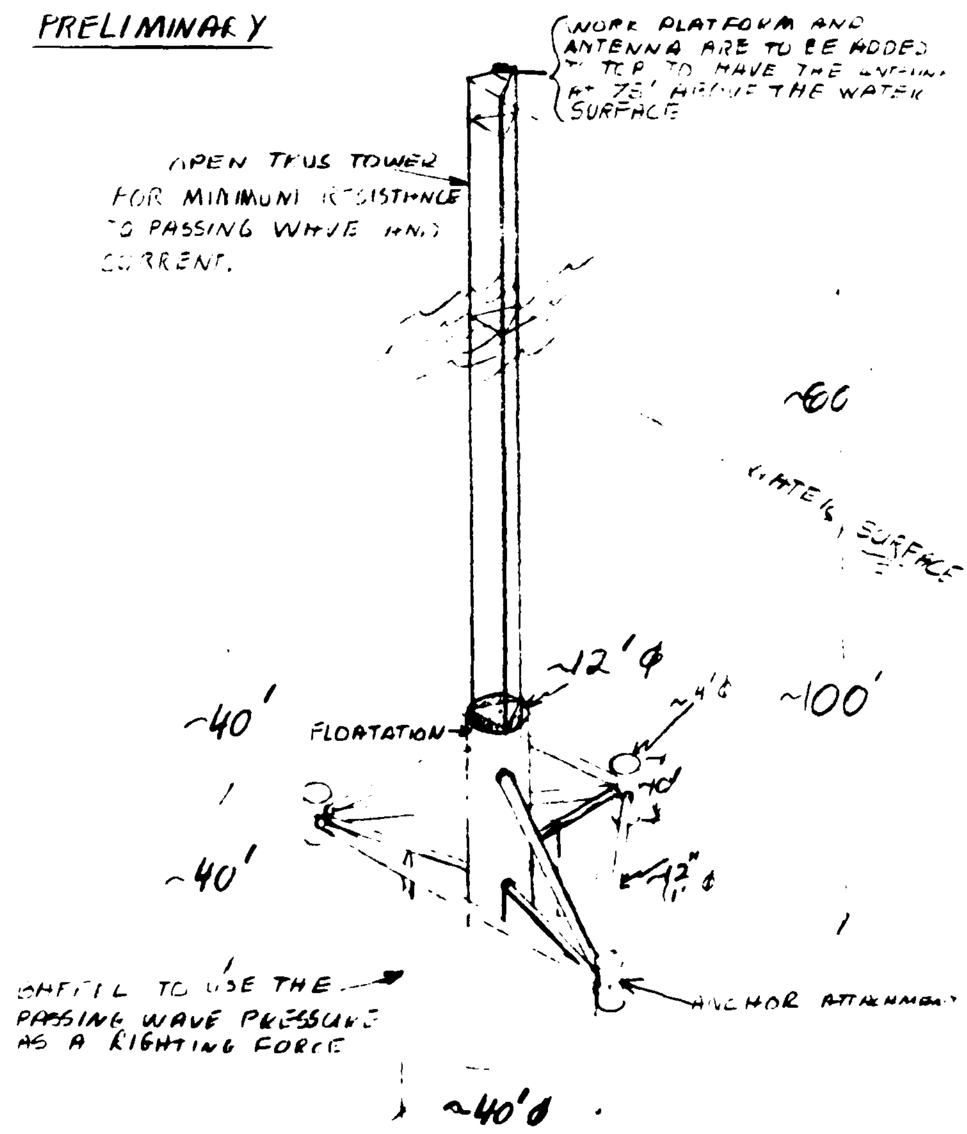


FIGURE 4.0-3 SKETCH OF SPAR BUOY CONCEPT



It was found that the baffel placed below the anchor attachment points did not contribute enough of a compensating force to offset the overturning forces. Because of this, the baffel was replaced with an equivalent weight which was moved further below the primary floatation. This resulted in a much greater separation between the center of buoyancy and center of gravity. This increased separation produced the needed righting moment.

The revised structural configuration was subjected to the operational environment and five consecutive waves to determine if the concept would conform to the $\pm 10^{\circ}$ roll, pitch and yaw constraint. The analysis indicated the structure assumes an initial angle of approximately $-5.5^{\circ}$ due to the wind and current. From this initial angle the variation in pitch ranges from $-10.5^{\circ}$ to $7.8^{\circ}$. The yaw is less than $\pm 1^{\circ}$. The pitch may be reduced by further separation of the center of buoyancy and center of gravity. A series of plots depicting the time history of the structure's movement can be found in Appendix C. After five waves had passed, the structure had moved along the water surface in the direction of the wave and current a distance of approximately 185 feet.

It is important to remember that the results presented in this report are for only one environmental loading condition. The chosen wind, wave, and current directions may not result in the maximum load but give an indication of the structure's response.

Preliminary analysis done on this concept, assuming the structure did not move, resulted in mooring line loads as high as 250,000 pounds for the survival condition. Allowing the structure a limited amount of movement in both the operational and survival environment results in lower mooring line loads of approximately 150,000 pounds during operation and approximately 160,000 pounds in survival condi-

tions. The plots of the structure's movement, found in Appendix D, for the 61.3 foot survival wave and 150 knot survival wind show the angle of pitch has increased. However, this increase is not enough to endanger the top deck on the tower. Also, the structure had moved approximately 320 feet after the five waves have passed. This lower mooring line load during the survival conditions results in a lower overall cost estimate.

No stiffness analysis was done on the structure for this report. It is assumed the individual members within the structure can be choosen so each will be strong enough to withstand the maximum loads.

### 4.2.2 Preliminary Cost Estimate

The first cost estimate prepared for the spar buoy concept was based on the original mooring line load of 250,000 pounds (see Table 4.0-1). It was also decided to use a Kevlar mooring line which has very little elongation. As seen in Table 4.0-1, the 3 Leg mooring cost is the most expensive part of this concept.

TABLE 4.0-1

Preliminary Cost Estimate for the Spar Buoy using Kevlar Mooring Lines.

| | |
|---|---|
| Site Survey | $ 150,000 |
| Material, Construction | 800,000 |
| 3 Leg Mooring | 5,216,000 |
| Installation (15 days) | |
| Equipment | 307,000 |
| Labor | 60,250 |
| A&E Design 6% Above except site survey | 383,000 |
| SIOH 10% Above | 638,325 |
| TOTAL (Present $) | $7,554,575 |

NOTE: Does Not Include Post Installation Inspection

Allowing the structure to have limited movement reduced the loads on the mooring lines. This load reduction together with the possibility of changing the mooring line material to a Polyester may substantially lower the cost of each moored structure. The polyester (Stable Braid) mooring line has approximately 2.5% elastic elongation when used at 20% of breaking strength, which is the working (operational) load. This is the lowest stretch standard double braid rope available. Table 4.0-2 is a summary of the cost estimate for the Spar buoy concept with the reduced mooring line loads and replacing the Kevlar with the polyester mooring line.

TABLE 4.0-2

Preliminary Cost Estimate for the Spar Buoy using Polyester Mooring Lines.

| | |
|---|---|
| Site Survey | $ 150,000 |
| Material/Construction | 800,000 |
| 3 Leg Mooring | 2,123,000 |
| Installation (15 days) | |
| Equipment | 307,000 |
| Labor | 60,250 |
| A&E Design 6% Above | |
| except site survey | 200,000 |
| SIOH 10% Above | 330,000 |
| TOTAL (Present $) | $3,970,000 |

NOTE: Does Not Include Post Installation Inspection

## 5.0 CONCLUSION

### 5.1 200 Foot Extension Concept

Placing a 200 foot, stand alone tower extension on the existing TACTS towers could reduce the factor of safety for compression failure of the pile foundation to 1.19.

Because the environmental loading condition responsible for this reduction in safety factor would not be long term, this value is felt to be satisfactory. This factor of safety was calculated based on the original strengths of the TACTS towers. Prior to the design of the extension, an extensive engineering analysis would be needed to ensure the towers have retained 100% of their original strength.

## 5.2 Shallow Water Range Expansion Concept

The use of a template structure would be the option with the lowest risk factor. The continuing successful use of the present TACTS range indicates this type of structure can endure the environment.

The installation of a guy wire tower may involve unseen problems that would increase the cost. As mentioned earlier in this report, the guy wire tower may have many more mooring legs than the three used in this report. This concept appears to have a lower preliminary cost estimate but there is a much higher risk factor with this concept than there is using a template structure.

The use of a floating structure was not addressed, therefore, the adequacy of this concept cannot be determined.

## 5.3 Deep Water Range Extension Concept

There is no way within the timeframe of this task to place a risk factor on this concept because no one has ever moored an unmanned platform, like the ones described in this report, in this water depth. The technology exists to accomplish the design and installa-

tion of this type of structure, however, the lack of experience could contribute to making this a very high risk undertaking. Even so, it is felt this concept could be successfully engineered. It is also important to consider that during the life of the structure, part or all of the mooring system may have to be replaced.

## 5.4 Floating Structure Maintenance

During the design life of the floating structures, each one should be removed from it's mooring and brought back to shore every five years. At this time the entire structure could be refurbished. The cost of this maintenance was not included in the cost estimate. Also, the impact of the down time for the range while this maintenance is being done has not been factored into the estimate.

## 5.5 Summary of Preliminary Cost Estimates

A summary of all the preliminary cost estimates can be found in Table 5.0-1. All the costs presented in this table are based on assumptions presented in this report.

TABLE 5.0-1

Summary of Preliminary Cost Estimates

| Concept | Present $ Cost |
|---|---|
| 200 Foot Extension | $600K |
| Fixed Template Tower | $5,000K |
| Guy Wire Tower | $1,404K |
| Spar Buoy Using Kevlar | $7,555K |
| Spar Buoy Using Polyester | $3,970K |

## REFERENCES

1. Tactical Aircrew Combat Training System (TACTS) Antenna Extension Feasibility Study, FPO-1 Technical Note TR-1E-40, January 1980

2. Chern, C., Feasibility Study on the Construction and Cost Estimate of an Offshore Microwave Antenna Support Tower, Key West, Florida; FPO-1, October 1980

# A

APPENDIX A

| | |
|---|---|
| **CHESAPEAKE DIVISION** Naval Facilities Engineering Command NDW | PROJECT: |
| DISCIPLINE | Station: |
| | E S R: Contract: |
| Calcs made by: date: | Calculations for: TOWER EXTENSION |
| Calcs ck'd by: date: | |

FACTOR OF SAFETY ANALYSIS

FOR THE

ADDITION OF A

200 FT EXTENSION ON

A 105 FT, 93 FT AND 81 FT

EXISTING TOWERS

BY ROTHKOPF 9/81
FROM CHERN 2/81



GPO 942-951

PRELIMINARY COST ESTIMATE

[illegible] FT ANTENNA SUPPORTING STRUCTURE EXTENSION

ON TACTICAL AIR COMBAT TRAINING SYSTEM TOWERS

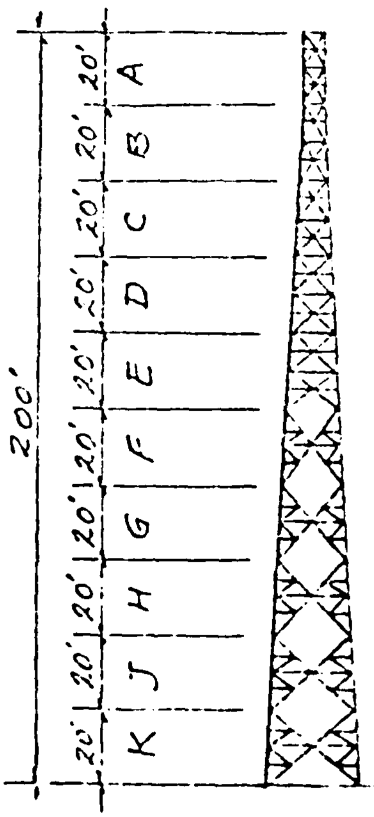
by C. CHEN
18 FEB 81

OCEAN ENGINEERING & CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, DC 20374

C. Chen
5-17-81

VI. CHARACTERISTICS OF 200 FT ANTENNA SUPPORTING TOWER

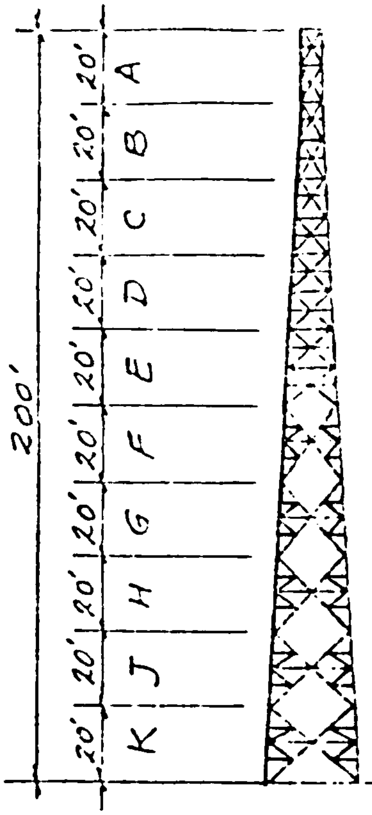
REF: FEASIBILITY STUDY ON THE CONSTRUCTION AND COST ESTIMATE OF AN OFFSHORE MICROWAVE ANTENNA SUPPORT TOWER, KEY WEST, FLORIDA by C. Chen 30 October 1980




| SECT. | BASE SPREAD | BASE SHEAR | BASE MOMENT | AXIAL REACTION |
|---|---|---|---|---|
| A | 5'-6" | 20,221 # | 353,530 k-# | 32,139 # |
| B | 7'-7" | 24,908 | 804,820 | 53,065 |
| C | 9-8 | 30,260 | 1,356,900 | 70,163 |
| D | 11-9 | 35,960 | 2,018,700 | 85,902 |
| E | 13-10 | 42,237 | 2,800,670 | 101,229 |
| F | 15-11 | 48,447 | 3,707,510 | 116,466 |
| G | 18-0 | 55,168 | 4,743,660 | 131,768 |
| H | 20-1 | 62,425 | 5,919,590 | 147,375 |
| J | 22-1 | 70,397 | 7,247,810 | 164,101 |
| K | 24-3 | 78,900 | 8,740,780 | 180,222 |

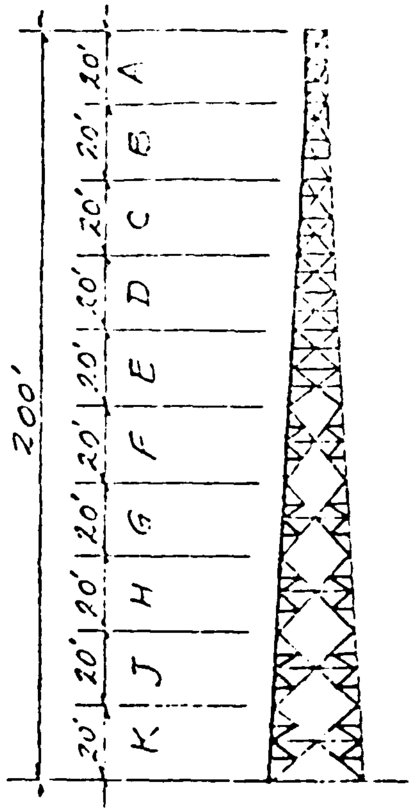
Note: FORCE COMPUTATIONS ARE FOR 140 MPH WIND AND 4 - 8'φ ANTENNA DISHES ON THE TOP OF TOWER.

C. Chang
2-17-81




| SECT. | SECT. WT. | TOTAL WT. | LEG REACTION |
|---|---|---|---|
| A | 2,372# | 2,372# | 593# |
| B | 2,210 | 4,582 | 1,146 |
| C | 2,903 | 7,485 | 1,871 |
| D | 3,040 | 10,525 | 2,631 |
| E | 3,271 | 13,796 | 3,449 |
| F | 3,668 | 17,464 | 4,366 |
| G | 3,878 | 21,342 | 5,335 |
| H | 4,090 | 25,432 | 6,358 |
| J | 4,740 | 30,172 | 7,543 |
| K | 4,951 | 35,123 | 8,781 |

C. Chen
[illegible]-17-81




| SECT. | AXIAL FORCE TENSION | AXIAL FORCE COMPRESS. | AXIAL STRESS TEN. | AXIAL STRESS COMP. |
|---|---|---|---|---|
| A | 31,546# | 32,732# | 5.80 ksi | 6.02 ksi |
| B | 51,919 | 54,211 | 9.54 | 9.97 |
| C | 68,292 | 72,034 | 9.84 | 10.38 |
| D | 83,271 | 88,533 | 12.00 | 12.76 |
| E | 97,780 | 104,678 | 14.09 | 15.08 |
| F | 112,100 | 120,832 | 13.28 | 14.32 |
| G | 126,433 | 137,103 | 14.98 | 16.24 |
| H | 141,017 | 153,733 | 16.71 | 18.21 |
| J | 156,558 | 171,644 | 16.09 | 17.64 |
| K | 171,441 | 189,003 | 17.62 | 19.42 |

C. Chern
2-17-81

(3) TACTS Tower Pile-Foundation Capacity

Ref: Design Calculations 105 FT MLTW Platform
C-E Crest Report No. 27-771-96 Vol. I.

Page 9.02 Pile Axial Loads

Max. Compressive Load = 2,931 kips

Max. Tensile Load = 2,010 kips

Ref: Foundation Analysis
C-E Crest Report No. 27-771-97

Ultimate Pile Capacity

| | |
|---|---|
| Compression | 4,000 kips |
| Tension | 3,400 kips |

C. Chen
2-17-?

ASSUME THAT ADDED DECK WEIGHT 10 TONS (?)

ADDED TENSION TO PILING

$$S_T = \frac{78.9 \times 180 + 8{,}741}{64 \cos 30°} - \frac{1}{8}(35 + 20)$$

$$= 395.6 \text{ KIPS}$$

ADDED COMPRESSION TO PILING

$$S_C = \frac{78.9 \times 180 + 8{,}741}{64 \cos 30°} + \frac{1}{8} \times (35 + 20)$$

$$= 432.3 \text{ KIPS}$$

MAX LOADS ON PILE

TENSION $\quad 395.6 + 2{,}010 = 2{,}405.6$ KIPS

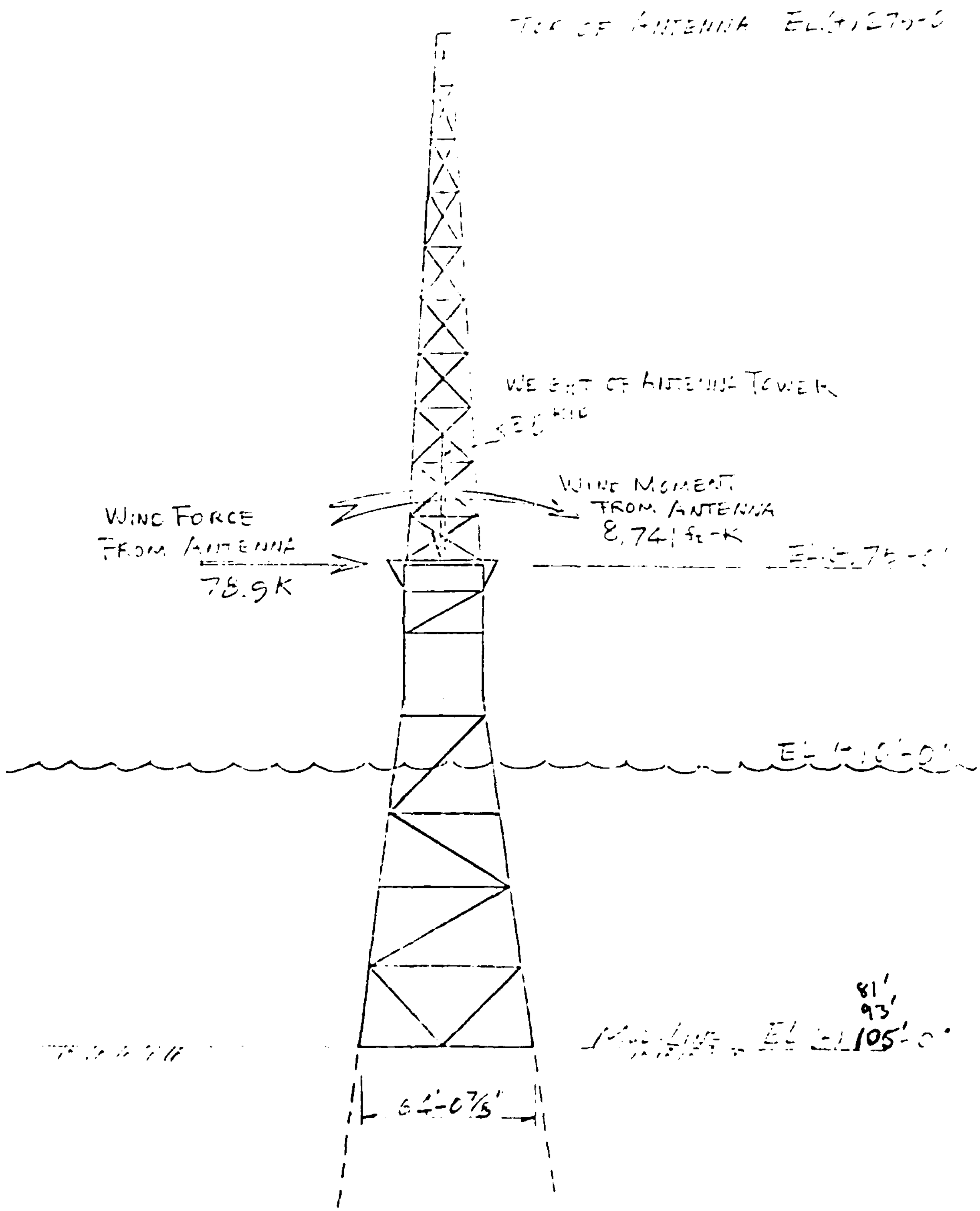
COMPRESSION $\quad 432.3 + 2{,}931 = 3{,}363.3$ KIPS

FACTOR OF SAFETY

COMPRESSION $\quad F.S. = \dfrac{4{,}000}{3{,}363.3} = 1.19$

TENSION $\quad F.S. = \dfrac{3{,}400}{2{,}405.6} = 1.41$

C. Chern


WEIGHT OF ANTENNA TOWER
WIND MOMENT FROM ANTENNA
8,741 ft-K
WIND FORCE FROM ANTENNA
78.9K
81'
93'
105'
64'-0 7/8'

| | |
|---|---|
| **CHESAPEAKE DIVISION** Naval Facilities Engineering Command NDW | PROJECT: TACTS |
| DISCIPLINE | Station: |
| | E S R: Contract: |
| Calcs made by: date: 9/19/91 | Calculations for: 20' EXT ON 81' TOWER |
| Calcs ck'd by: date: | |

(E) TACTS TOWER PILE – FOUNDATION CAPACITY:

REF: DESIGN CALC'S 81' MLW PLATFORM
C-E CREST RPT # 27-771-94

PG. 9.OA PILE AXIAL LOADS:

MAX COMPRESSIVE LOAD: 2409 KIPS

MAX TENSION LOAD: 1746 KIPS

REF: FOUNDATION ANALYSIS
C-E CREST RPT # 27-771-97

ULTIMATE PILE CAPACITY:

COMPRESSION: 4000 KIPS

TENSION: 3400 KIPS

* ASSUME THAT ADDED DECK WEIGHS 20 KIPS

ADDED TENSION TO PILING:

$$Q_T = \frac{[78.9 \times (75 + 81)] + 8741}{64 \cos 30^\circ} - \frac{1}{3}(35 + 20)$$

$= 361.4$ KIPS



GPO 942-99

| CHESAPEAKE DIVISION<br>Naval Facilities Engineering Command NDW<br>DISCIPLINE | PROJECT: FACTS<br>Station:<br>E S R: Contract: |
|---|---|
| Calcs made by: [illegible] date: 6/9/81<br>Calcs ck'd by: date: | Calculations for: 800' EXT. ON 8A TOWER |

APPLIED COMPRESSION TO PILING:

$$Q_c = \frac{[78.9 \times (75+81)] + 8741}{64 \cos 30^\circ} + \frac{1}{2}(35+20)$$

$$= 398.1 \text{ KIPS}$$

MAX. LOADS ON PILE:

TENSION: $361.4 + 1746 = 2107.4$ KIPS

COMPRESSION: $398.1 + 2409 = 2807.1$ KIPS

FACTOR OF SAFETY:

COMPRESSION: $F.S. = \frac{4000}{2807.1} = 1.42$

TENSION: $F.S. = \frac{3400}{2107.4} = 1.61$

| CHESAPEAKE DIVISION | PROJECT: TACTS |
|---|---|
| Naval Facilities Engineering Command NDW | Station: |
| DISCIPLINE | E S R: Contract: |
| Calcs made by: [illegible] date: 9/9/81 | Calculations for: 200' EXT ON 93' TOWER |
| Calcs ck'd by: date: | |

(I) TACTS TOWER PILE-FOUNDATION CAPACITY:

REF. DESIGN CALC'S 93 FT MLW PLATFORM
GE CREST RPT. # 27-771-95

TC. 9.02 PILE AXIAL LOADS:

MAX COMPRESSIVE LOAD 2914 KIPS
MAX TENSILE LOAD 1985.07 KIPS

REF. FOUNDATION ANALYSIS:
C-E CREST RPT. # 27-771-97

ULTIMATE PILE CAPACITY:

COMPRESSION: 4000 KIPS

TENSION: 3400 KIPS

* ASSUME THAT ADDED DECK WEIGHS 20 KIPS.

ADDED TENSION TO PILING:

$$Q_T = \frac{[78.9 \times (75+93)] + 8741}{64 \cos 30^\circ} - \frac{1}{3}(35+20)$$

$$= 378.5 \text{ KIPS}$$



GPO 842-981

| CHESAPEAKE DIVISION<br>Naval Facilities Engineering Command NDW<br>DISCIPLINE | PROJECT: TACTS<br>Station:<br>E S R: Contract: |
|---|---|
| Calcs made by: [illegible] date: 9/9/81<br>Calcs ck'd by: date: | Calculations for: 200' EXT on 93' TOWER |

ADDED COMPRESSION TO PILING:

$$Q_c = \frac{[78.9 \times (75+93)] + 8741}{64 \cos 30°} + \frac{1}{3}(35+20)$$

$$= 415.2 \text{ KIPS}$$

MAX LOADS ON PILE:

TENSION : 378.5 + 1985.07 = 2363.6 KIPS

COMPRESSION: 415.2 + 2914 = 3329.2 KIPS

FACTOR OF SAFETY:

COMPRESSION : $F.S. = \frac{4000}{3329.2} = 1.20$

TENSION: $F.S. = \frac{3400}{2363.6} = 1.44$

| CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW | PROJECT: ECTACTS |
|---|---|
| DISCIPLINE EPO-1 | Station: |
| | E S R: Contract: |
| Calcs made by: J.O. Boyle date: 1/25/81 | Calculations for: |
| Calcs ck'd by: date: | |

200 FT TOWER EXTENSION
PRELIMINARY COST ESTIMATE

1) MATERIALS

- Tower 40,000# @ $1.75/lb — $70,000
  Lader & Safeclimb devise $10.25/ft + $400 — 2,450
  lights — 2,300
  — $74,750

- Added Deck Mod 25000# @ $1.75/lb — $43,750

- Handling Fee 5% Above — 6,000

$124,500 ←

2) EQUIPMENT RENTAL
NORFOLK PRESENT $

- 60 ton Derric Boat & Small 120'x40' barge } $175/day — ~$9675/day
- Equipment Barge 220'x60' — ~$1550/day
- Tug & fuel & Crew — ~$6000/day
- Crew Boat (Oregon Inlet) — ~$1200/day

page 1 of

GPO 942-951

| CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW | PROJECT: E-TACTS |
|---|---|
| DISCIPLINE FPO-1 | Station: |
| | E S R: Contract: |
| Calcs made by: T. O'Boyle date: 9/25/81 | Calculations for: |
| Calcs ck'd by: date: | |

3) INSTALLATION

A) TACTS PLATFORM ADDED DECK

- Barge load on & Tie down 3 @ $75
- Derric Boat Round trip to site & install 3+1 @ $9675
- Barge demob 1 @ $75
- Tug 3+1 @ $6000
- Crew boat for erectors 3+1 4 @ $1200

(3×75) + (4×9675) + 75 + (4×6000) + (4×1200) = **$67,800** ←

B) TOWER EXTENSION

- Material Barge (days)
  - Mob, Load on, tiedown 3
  - Transit to site - off load part of tower & transit back 6 × 2 day 12
  - Tied to pier during erection 9
  - Weather 6
  - Demobe 3
  - 33 days

- Tug for Material Barge
  - Transit to site to offload & return 6 × 2 day 12
  - Weather 3
  - 15 days



GPO 942-951

| CHESAPEAKE DIVISION | PROJECT: ECTACTS |
|---|---|
| Naval Facilities Engineering Command NDW | Station: |
| DISCIPLINE FPO-1 | E S R: Contract: |
| Calcs made by: J O'Boyle date: 1/25/81 | Calculations for: |
| Calcs ck'd by: date: | |

- Crew Boat

- Installation 15
- off load part of tower 6
- weather 6

= 27

(33 x 1550) + (15 x 6000) + (27 x 1200) = $173,550

4) LABOR

1 Super $490/day
1 Inspector $490/day
6 man crew $360/day (each)

| | onsite | weather | total |
|---|---|---|---|
| - Added Deck (All) | 3 + 3 | 1 | 7 |
| - Tower extension | | | |
| • off load (6 man crew only) | 6 + 3 | | 9 |
| • Errection (All) | 15 | 6 | 21 |

(490 x 28) + (490 x 28) + (360 x 6 x 37) = $107360

Perdiem 37 x 50 x 8 = 14800

Travel 8 x 500 = 4000

$126,160



GPO 942-951

**CHESAPEAKE DIVISION**
**Naval Facilities Engineering Command NDW**
**DISCIPLINE** EPO-1
**Calcs made by:** T. O'Boyle **date:** 9/25/81
**Calcs ck'd by:** ______ **date:** ______

**PROJECT:** ECTHCTS
**Station:** ______
**E S R:** ______ **Contract:** ______
**Calculations for:** ______

SUMMARY

| | |
|---|---|
| • MATERIAL | $104,500 |
| • LABOR | 126,160 |
| • INSTALLATION | |
| - Platform Mod | 67,800 |
| - Tower | 173,550 |
| | $472010 |
| • A&E Design including Platform Mod 10% Above | 49,200 |
| • S/OH 10% Above | 49,200 |
| | $570,410 |

PRESENT $ TOTAL $600,000

* Does Not Include Antenna Cost



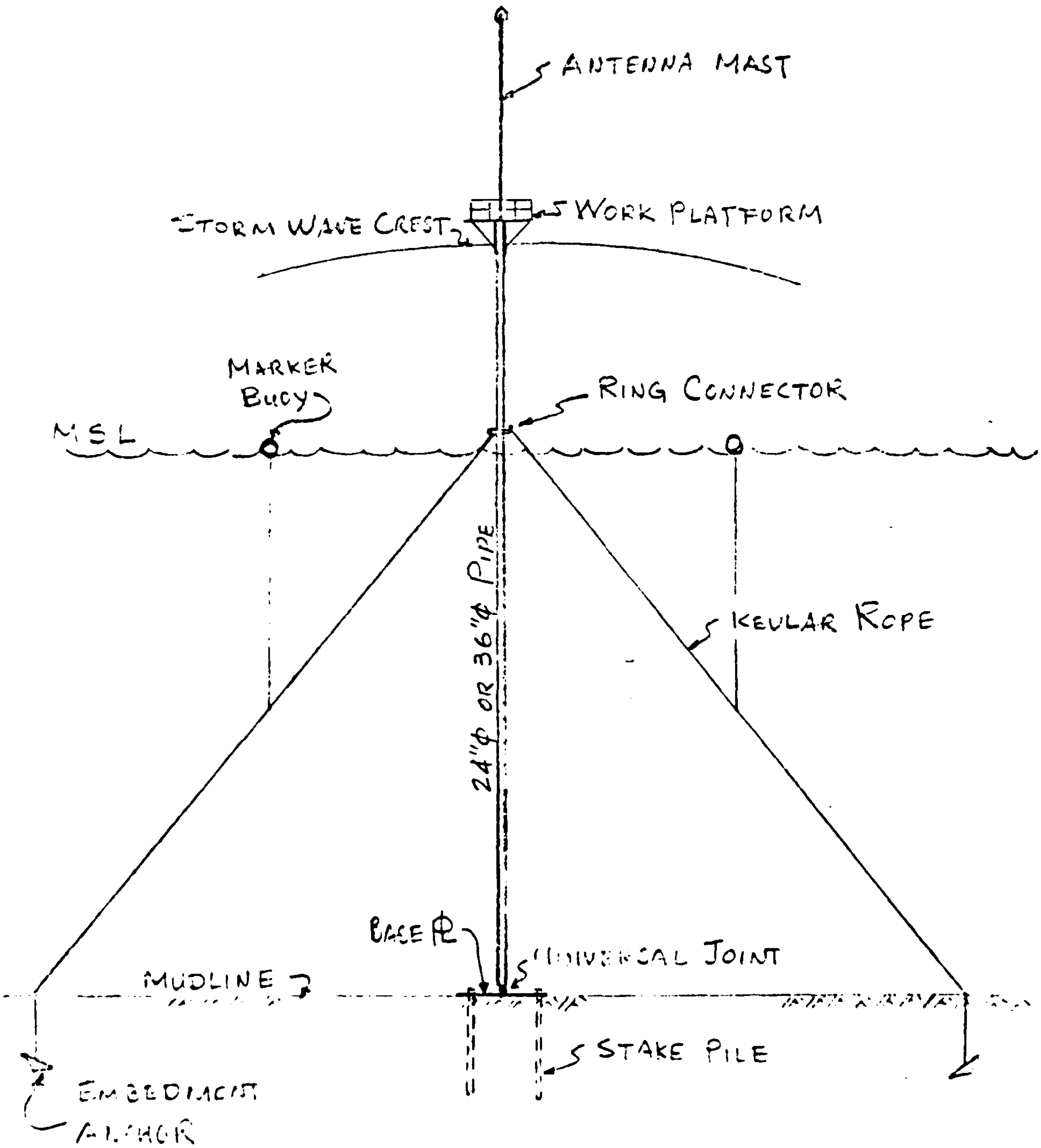
GPO 942-951

# B

APPENDIX B

# NAVAL FACILITIES ENGINEERING COMMAND

BY C. Chern DATE 8/31/81 SUBJECT TACTS EXTRA CONCEPT BOOK NO. ______
CHKD. BY ______ DATE ______ ______ PAGE NO. ______
IN BOOK ______ PAGE ______ ______ JOB NO. ______



C. Chern

DATE 1[illegible] AUGUST 1981

PROJECT TITLE TACTS EXTRA CONCEPT STUDY

++++++++++++++
INPUT DATA
++++++++++++++

WAVE CHARACTERISTICS
MEAN LOW WATER DEPTH (FEET) = 1[illegible]
WAVE HEIGHT (FEET) = [illegible]
WAVE PERIOD (SECONDS) = 1[illegible]
ASTRONOMICAL TIDE (FEET) = [illegible]
STORM TIDE (FEET) = [illegible]
SURFACE CURRENT (FT/SEC) = 4.[illegible]

WAVE APPROACHING ANGLE (DEGREES) [illegible]

MEMBER AND HYDRODYNAMICS CHARACTERISTICS
PILE DIAMETER (INCHES) = 24
DRAG COEFFICIENT = .6
INERTIA COEFFICIENT = 1.5

MESH POINT COORDINATES FOR PRESSURE COMPUTATION
X-DISTANCE FROM CREST (FEET)
-15 0 15

Y-ELEVATION ABOVE MUD-LINE (FEET)
[illegible] [illegible] [illegible] 80 100 [illegible] 120 14[illegible] 15[illegible] [illegible]

+++++++++++++++
OUTPUT DATA
+++++++++++++++

CALCULATED WAVE LENGTH (FEET) = 795.294

X-DISTANCE FROM CREST (FEET)
-1[illegible] [illegible] 15
WATER SURFACE ABOVE MUD-LINE (FEET)
149.[illegible] [illegible] 1[illegible]

MESH POINTS WHICH ARE USED TO COMPUTE PRESSURES
Y-ELEVATION ABOVE MUD-LINE (FEET)

| | | |
|---|---|---|
| 149.[illegible] | 150.[illegible] | 14[illegible] |
| [illegible] | 1[illegible] | 14[illegible] |
| [illegible] | 140 | 1[illegible] |
| [illegible] | [illegible] | 1[illegible] |
| [illegible] | 120 | 1[illegible] |
| 1[illegible] | 100 | 100 |
| [illegible] | 80 | 80 |
| [illegible] | [illegible] | [illegible] |
| 40 | 40 | 40 |
| 2[illegible] | [illegible] | 2[illegible] |

1

C. Chen

WAVE APPROACHING ANGLE (DEGREES) = 0

WAVE PRESSURE IN X-DIRECTION (LBS/FT LENGTH)

| | | |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| 1104 | 11[illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| 760 | 741 | [illegible] |
| 552 | [illegible] | [illegible] |
| 456 | 478 | 4[illegible] |
| [illegible] | 41[illegible] | 4[illegible] |
| [illegible] | [illegible] | [illegible] |

WAVE PRESSURE IN Y-DIRECTION (LBS/FT LENGTH)

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | |
| [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | |

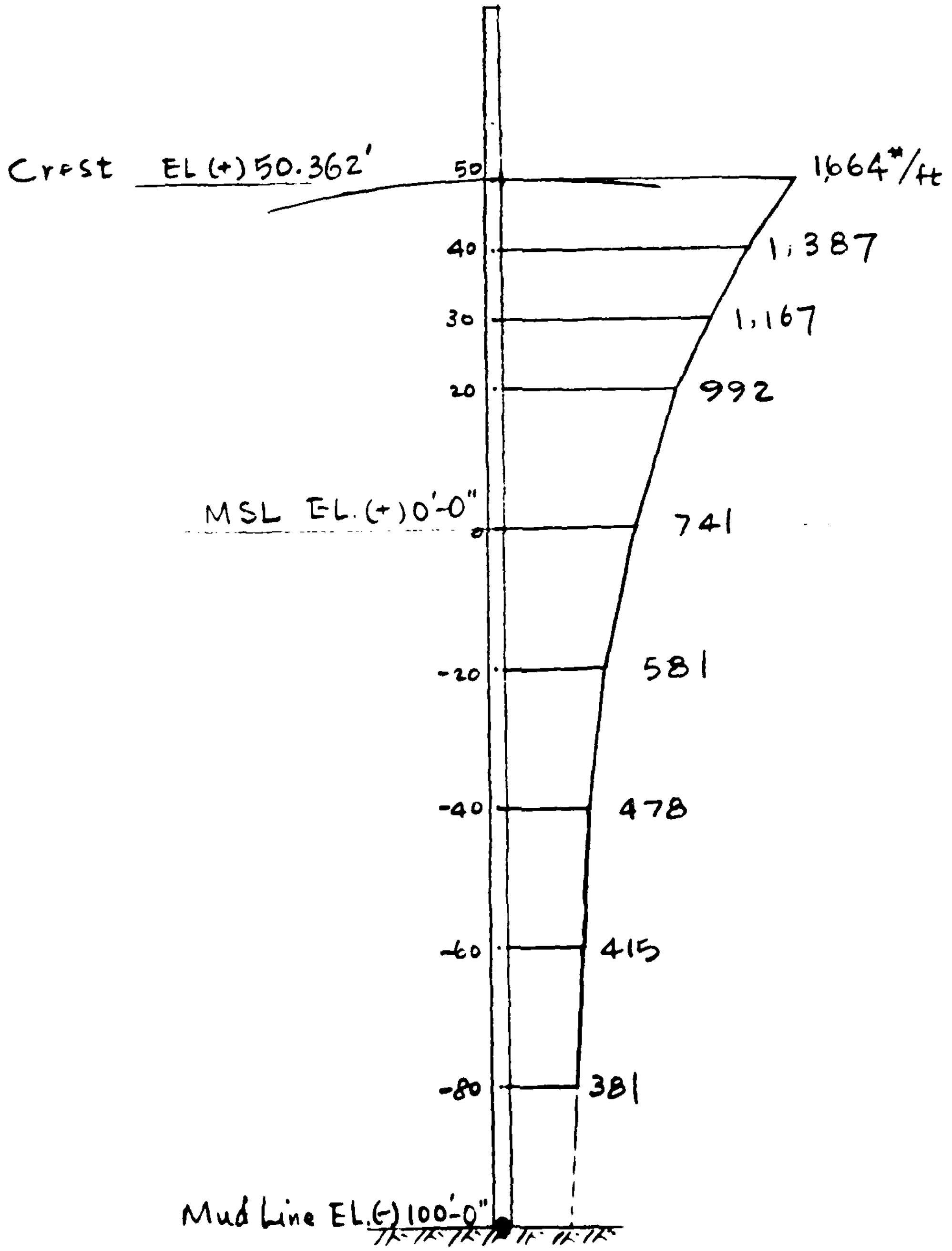
++++++++++++
FINIS
++++++++++++

NAVAL FACILITIES ENGINEERING COMMAND

BY C. Chern DATE 8/19/81 SUBJECT TACTS EXTRA CONCEPT BOOK NO. ______

CHKD. BY ______ DATE ______ ______ PAGE NO. ______

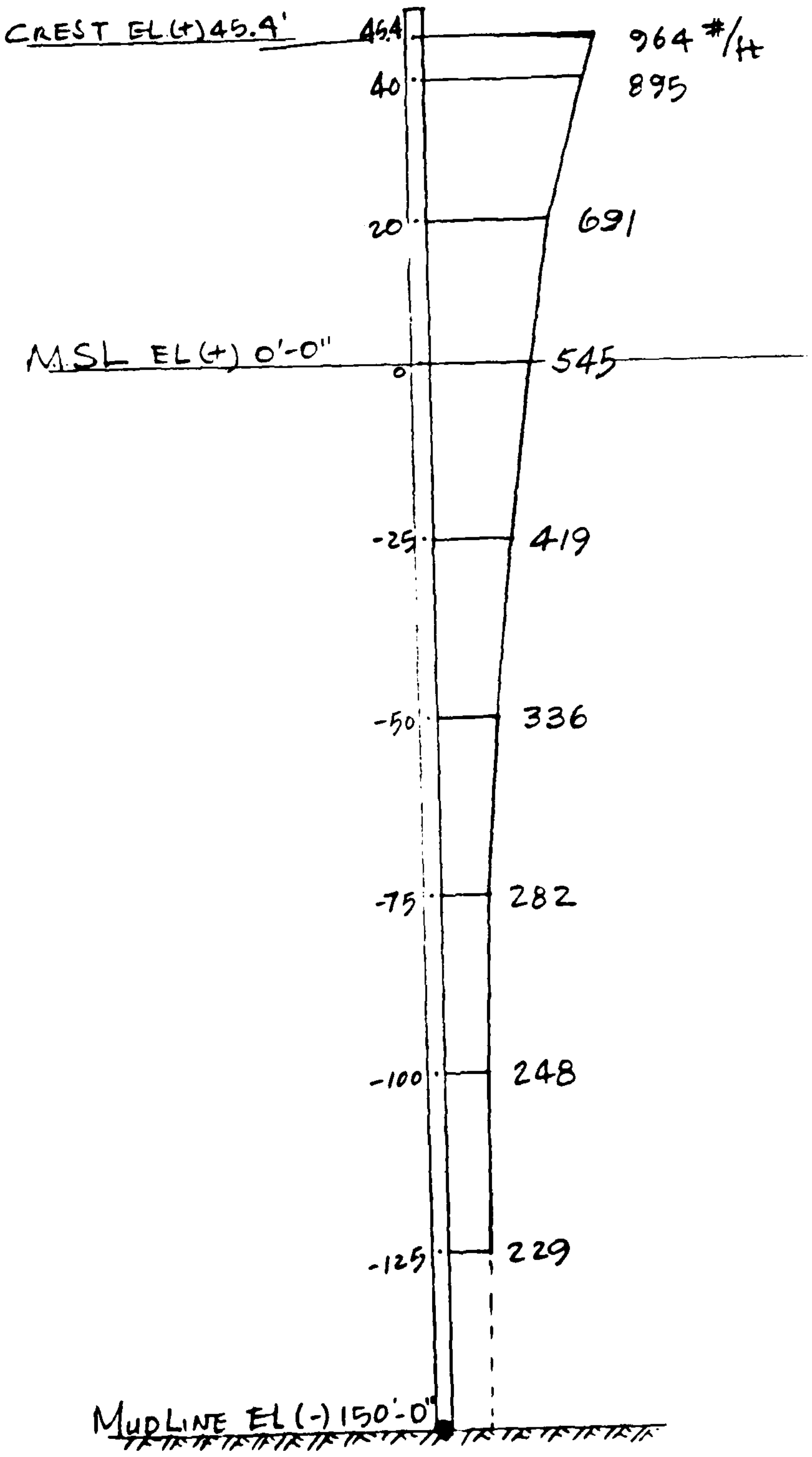
IN BOOK ______ PAGE ______ ______ JOB NO. ______



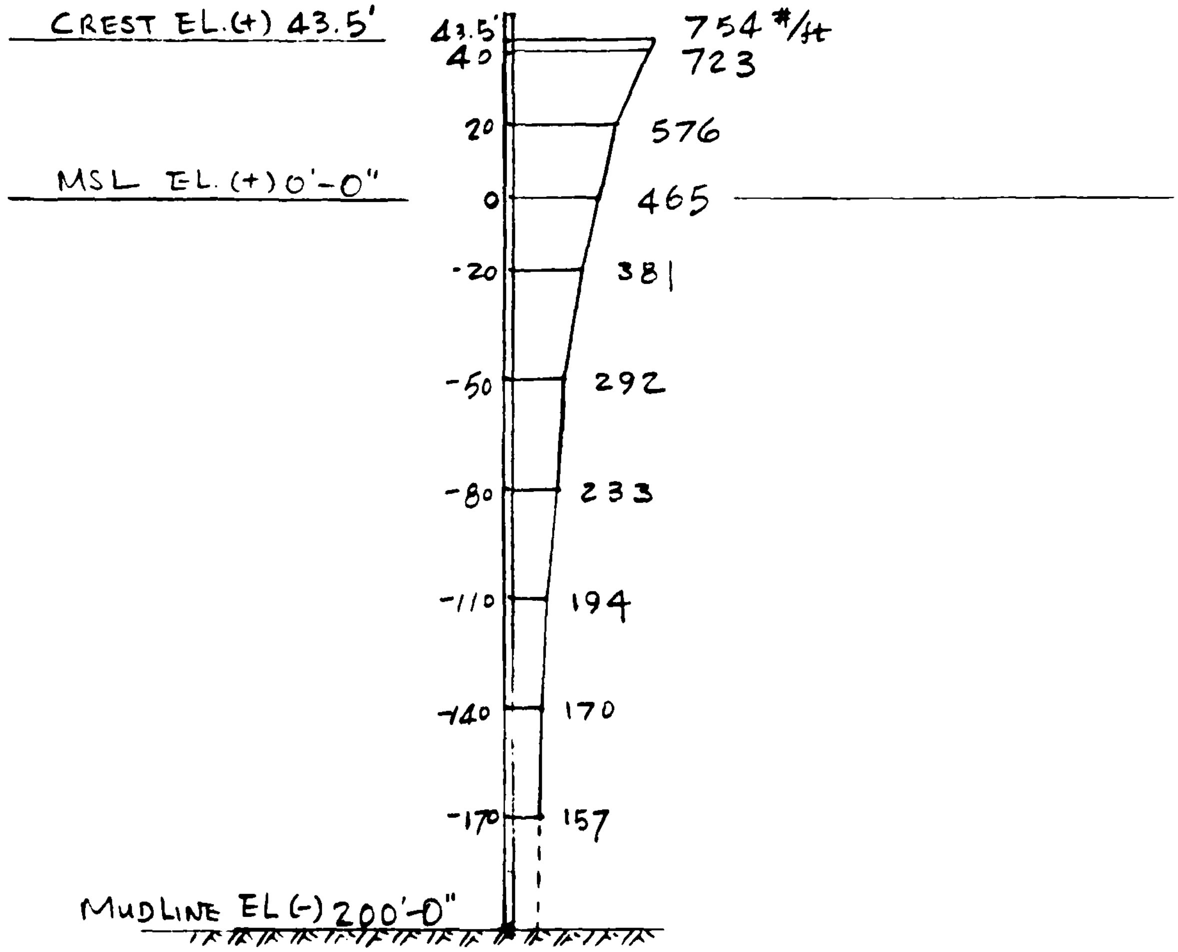

WAVE FORCE DISTRIBUTION – 24"Φ PIPE @ 100' WATER DEPTH

NAVAL FACILITIES ENGINEERING COMMAND

BY C. Chern DATE 8/19/81 SUBJECT TACTS EXTRA CONCEPT BOOK NO. ______
CHKD. BY ______ DATE ______ PAGE NO. ______
IN BOOK ______ PAGE ______ JOB NO. ______



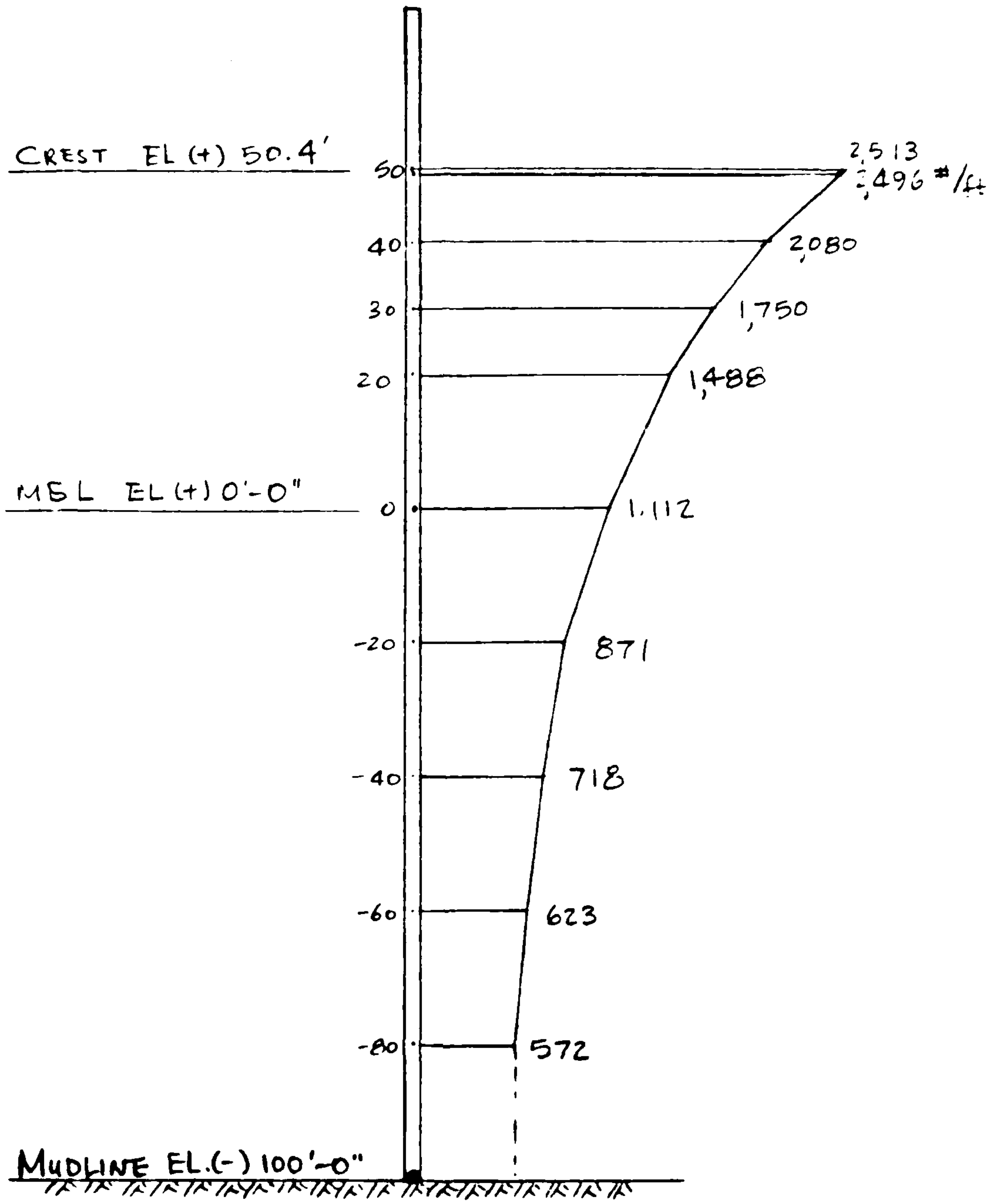

WAVE FORCE DISTRIBUTION – 24"Φ PIPE @ 150' WATER DEPTH




WAVE FORCE DISTRIBUTION - 24"Φ PIPE @ 200' WATER DEPTH

**NAVAL FACILITIES ENGINEERING COMMAND**

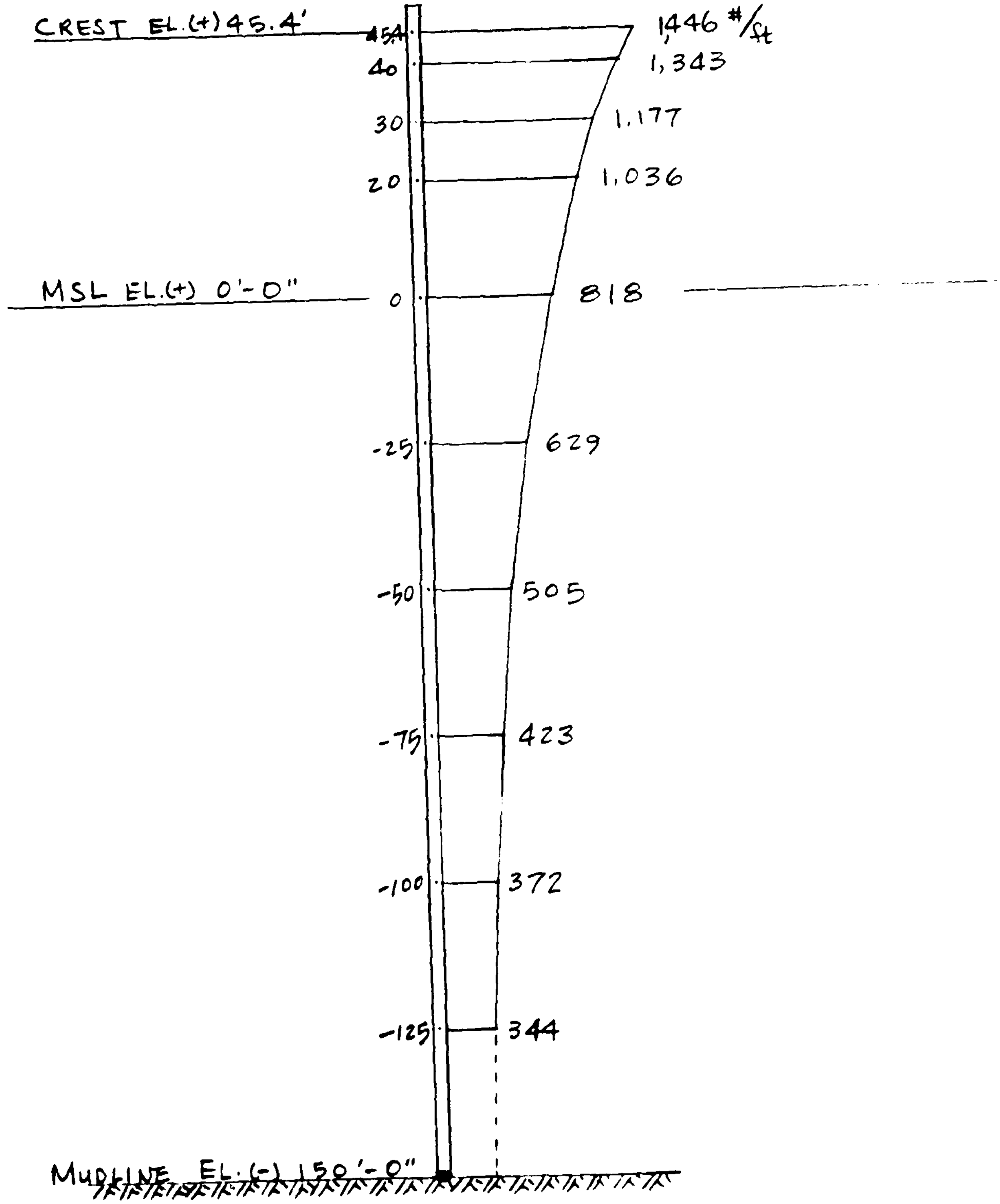
BY C. Chern DATE 8/19/81 SUBJECT TACTS EXTRA CONCEPT BOOK NO. ______
CHKD. BY ______ DATE ______ ______ PAGE NO. ______
IN BOOK ______ PAGE ______ ______ JOB NO. ______




WAVE FORCE DISTRIBUTION - 36" $\phi$ PIPE @ 100' WATER DEPTH

## NAVAL FACILITIES ENGINEERING COMMAND

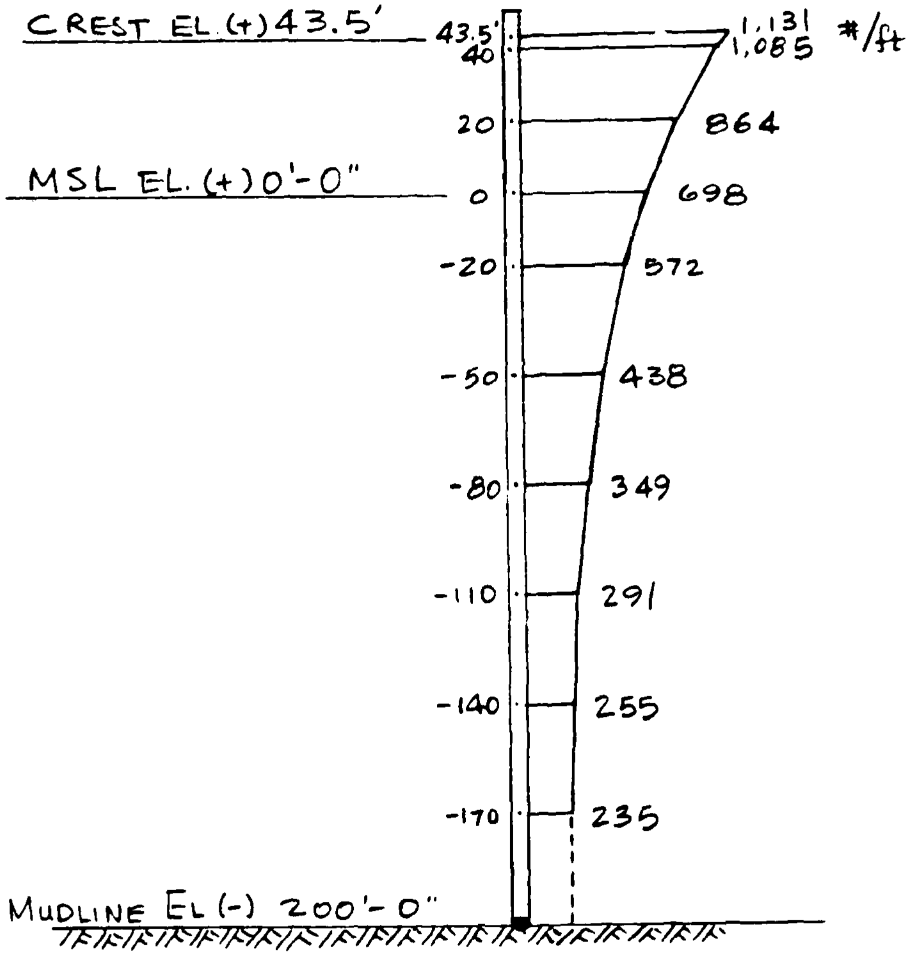
BY C. Chern DATE 8/21/81 SUBJECT TACTS EXTRA CONCEPT BOOK NO. ______
CHKD. BY ______ DATE ______ ______ PAGE NO. ______
IN BOOK ______ PAGE ______ ______ JOB NO. ______




WAVE FORCE DISTRIBUTION – 36"Φ PIPE @ 150' WATER

## NAVAL FACILITIES ENGINEERING COMMAND

BY C. Chern DATE 8/21/81 SUBJECT TACTS EXTRA CONCEPT BOOK NO. ______
CHKD. BY ______ DATE ______ ______ PAGE NO. ______
IN BOOK ______ PAGE ______ ______ JOB NO. ______




WAVE FORCE DISTRIBUTION - 36"Φ PIPE @ 200' WATER

**CHESAPEAKE DIVISION**
**Naval Facilities Engineering Command NDW**

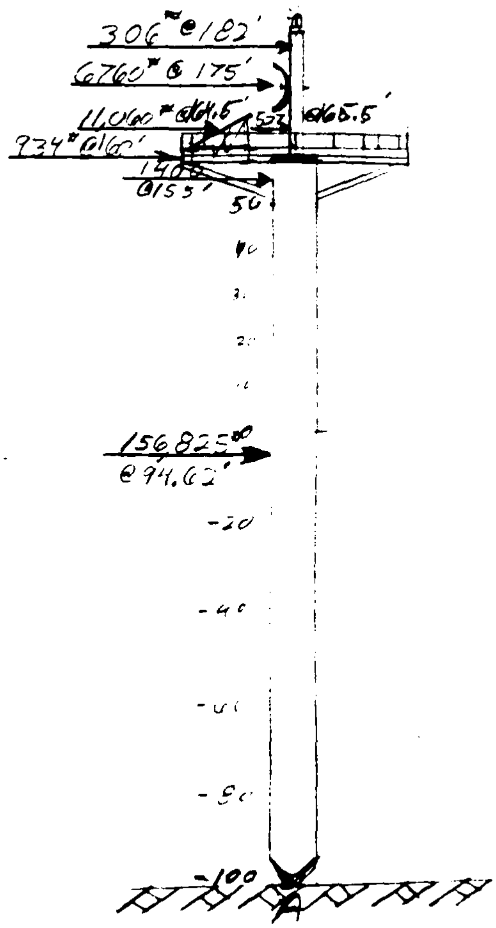
| | |
|---|---|
| DISCIPLINE FPO-1 | PROJECT: EC TACTS |
| | Station: |
| | E S R: Contract: |
| Calcs made by: T. O'Boyle date: 8/24/8 | Calculations for: Guywire Tower (Micro-Wave) |
| Calcs ck'd by: date: | |

Wind and Wave Forces On Tower
(Design Conditions)

36" ø in 100' water

Wind

Wave




$$\Sigma M_A = 0 = (306)(182) + (6760)(175) + (527)(165.5) + 11060(164.5)$$
$$+ (934)(160) - (1400)(155) - (156825)(94.62)$$
$$- YH$$

$$0 = 3511720.5 + 156{,}825(94.62) - Y$$

$$YH = 18{,}350.5 \text{ 'Kip}$$

page ___ of ___

GPO 942-951

| | |
|---|---|
| **CHESAPEAKE DIVISION**<br>Naval Facilities Engineering Command NDW<br>DISCIPLINE [illegible] | PROJECT: EC TAC[illegible]<br>Station:<br>E S R: Contract: |
| Calcs made by: [illegible] date: [illegible]<br>Calcs ck'd by: date: | Calculations for: Guy Vane Tower (Micro Wave) |

Y = height off the bottom

H = horizontal load

36"Ø
100' water

| Y (ft) | | H (Kips) |
|---|---|---|
| 60 | -40 | 305.8 |
| [illegible] | -30 | 262.2 |
| [illegible] | -20 | 229.4 |
| [illegible] | -10 | 203.9 |
| [illegible]0 | surface | 183.5 |
| [illegible]0 | 10 | 156.6 |
| [illegible] | 20 | 152.9 |
| [illegible] | 30 | 141.2 |
| 140 | 40 | 131.1 |

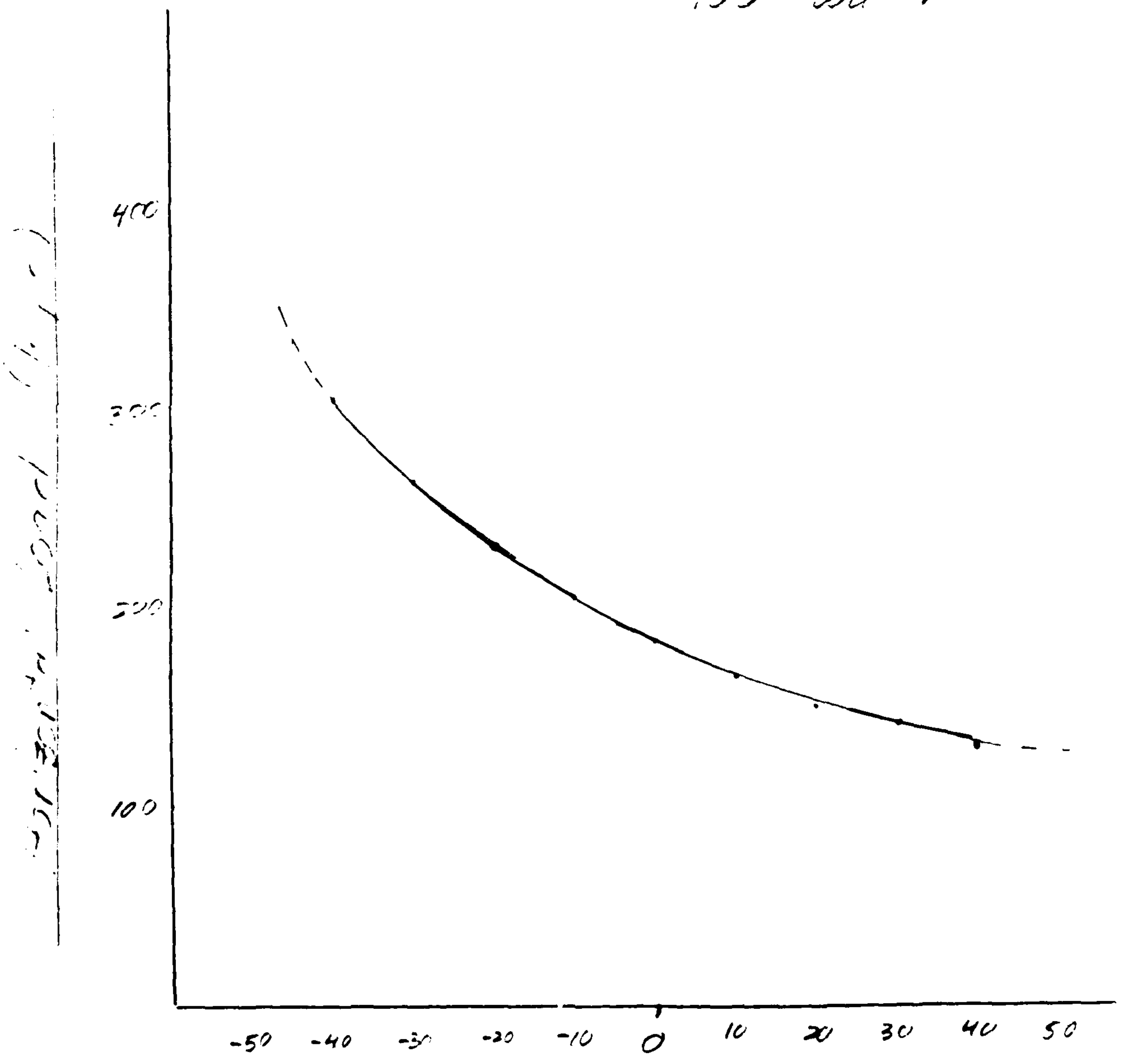
page ___ of ___

GPO 942-951

| | |
|---|---|
| **CHESAPEAKE DIVISION** | **PROJECT:** ECTACTS |
| **Naval Facilities Engineering Command NDW** | **Station:** |
| **DISCIPLINE** E99-1 | **E S R:** **Contract:** |
| **Calcs made by:** T. O'Boyle **date:** | **Calculations for:** Guy Wire Tower Micro Wave |
| **Calcs ck'd by:** **date:** | |

TOTAL HORIZONTAL FORCE AT ANCHOR CONNECTION

36' ø pipe
100' water

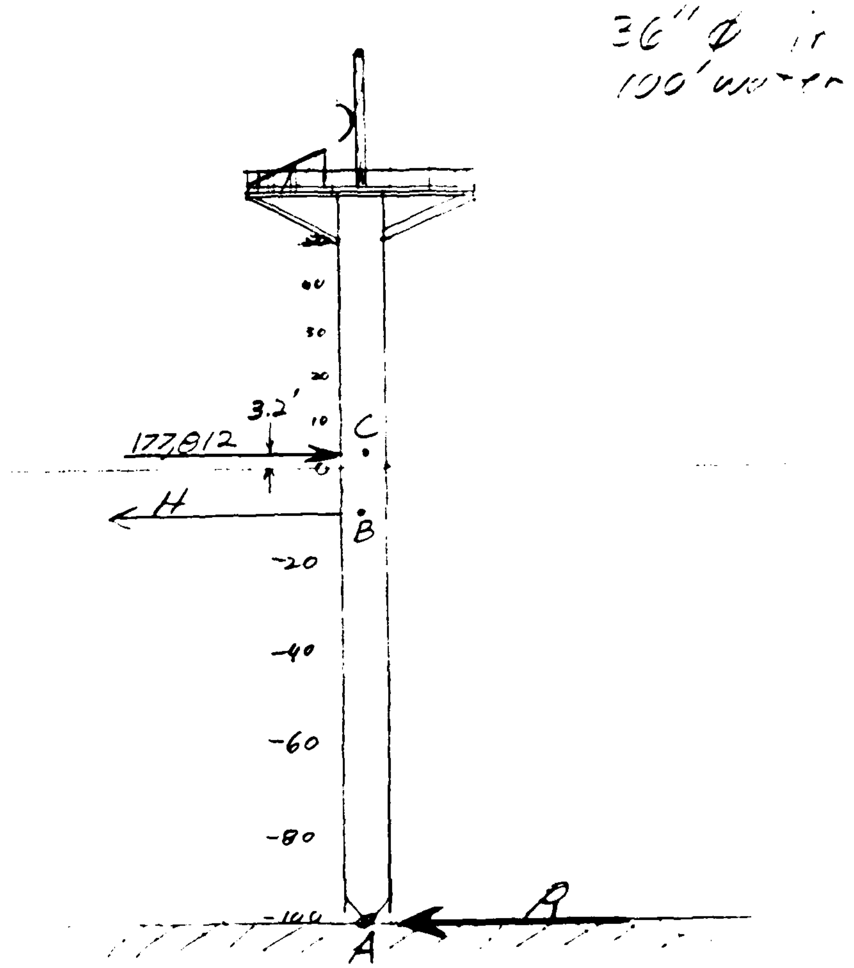



Distance from surface to Connection **page** ___ **of** ___

GPO 942-951

| CHESAPEAKE DIVISION | PROJECT: FC TACTS |
|---|---|
| Naval Facilities Engineering Command NDW | Station: |
| DISCIPLINE FPO-1 | E S R: Contract: |
| Calcs made by: T. O'Boyle date: 8/30/8 | Calculations for: |
| Calcs ck'd by: date: | Wind-Wave |

Equivalent TOTAL Force & Location




$F_T$ = TOTAL Force (wind + wave) = 177,812#

Location = $\Sigma M_A / F_T$ = $\frac{18350502}{177812}$ = 103.2 ft from bottom

or +3.2'

page ___ of ___

GPO 942-951

| **CHESAPEAKE DIVISION**<br>Naval Facilities Engineering Command NDW<br>DISCIPLINE FHC-1 | PROJECT: ECTACTS<br>Station:<br>E S R: Contract: |
|---|---|
| Calcs made by: [illegible] date: [illegible]<br>Calcs ck'd by: date: | Calculations for: Guy Wire Tower (Micro-Wave) |

TOTAL Reaction at Seafloor with anchor connected at various locations.

(using same sign convention) [illegible]

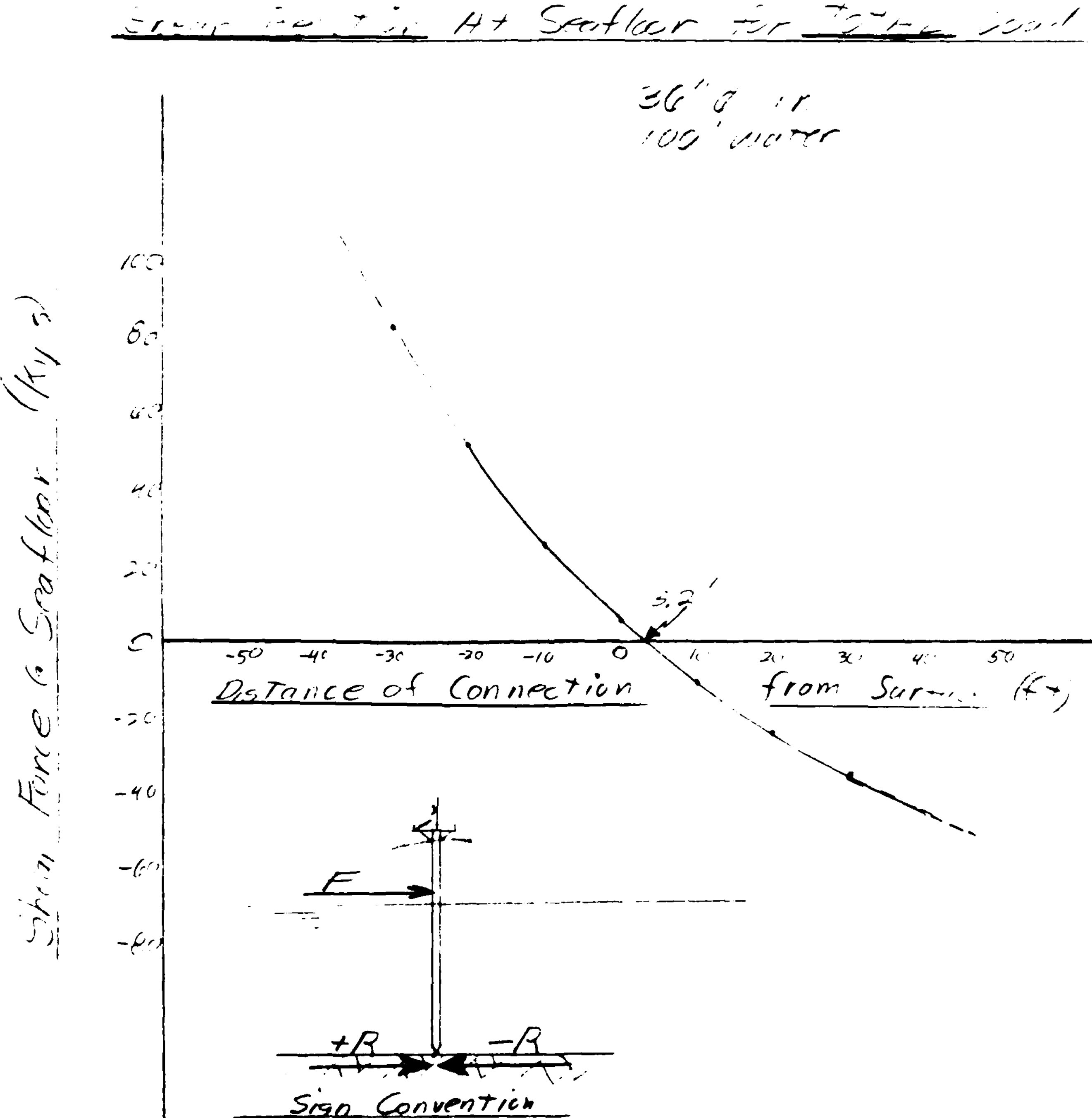
$$|R| = \frac{\overline{EC}\ 1778.2}{\overline{AE}}$$

| / | $\overline{EC}$ | $\overline{AE}$ | R |
|---|---|---|---|
| 40 | 36.8 | 140 | -46,739 |
| [illegible] | 26.5 | 130 | -3[illegible] |
| [illegible] | 16.8 | 120 | -24,894 |
| [illegible] | [illegible] | [illegible] | -10,992 |
| [illegible] | 3.2 | 100 | 5,690 |
| -1[illegible] | [illegible] | [illegible] | 2[illegible] |
| -2[illegible] | 23.2 | 8[illegible] | 51,5[illegible] |
| -30 | 33.2 | 70 | 84,334 |



GPO 942-951

| | |
|---|---|
| **CHESAPEAKE DIVISION**<br>Naval Facilities Engineering Command NDW<br>DISCIPLINE FPO-1 | PROJECT: EC THCTS<br>Station:<br>E S R: Contract: |
| Calcs made by: T. O'Boyle date: 4/26/81<br>Calcs ck'd by: date: | Calculations for: Guy Wire Tower Micro-Wave |




page ___ of ___

GPO 942-951

| **CHESAPEAKE DIVISION** Naval Facilities Engineering Command NDW | PROJECT: IC TACTS |
|---|---|
| DISCIPLINE FPO-1 | Station: |
| | E S R: Contract: |
| Calcs made by: T. O'Boyle date: 8/5/81 | Calculations for: Guy Line Tower |
| Calcs ck'd by: date: | [illegible] |

## Preliminary Mooring Design

[illegible]: Water Depth = 100 ft

Max Horizontal Load = 225 kips

∡ at anchor = 0°

Working load factor = 25% breaking

Stud link chain

3½" grade 2

10500 #/90' shot

116.67 #/ft dry

.87 × 116.67 = 101.5 #/ft wet

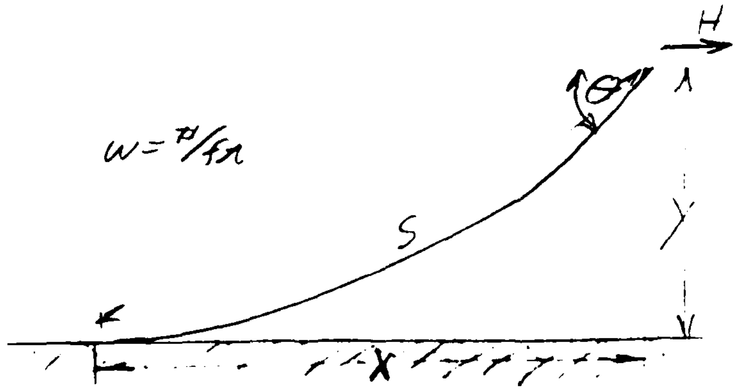
## Catenary Equations

"with 0° ∡ @ anchor"

$\theta = \tan^{-1}(Sw/H)$

$y = H/w\,(\sec\theta - 1)$

$x = H/w\,\ln[\tan(45 + \theta/2)]$




page ___ of ___

GPO 942-951

| CHESAPEAKE DIVISION | PROJECT: EC TECTS |
|---|---|
| Naval Facilities Engineering Command NDW | Station: |
| DISCIPLINE FPO-1 | E S R: Contract: |
| Calcs made by: T. O'Boyle date: | Calculations for: Guy Wire Tower (Micro-Wave) |
| Calcs ck'd by: date: | |

$$\boxed{l = \frac{H}{w}(\sec\theta - 1)} \qquad \sec\theta = \frac{1}{\cos\theta}$$

$$l\,\frac{w}{H} + 1 = \sec\theta$$

$$\frac{1}{l\frac{w}{H} + 1} = \cos\theta$$

$$\theta = \cos^{-1}\left[\frac{1}{l\frac{w}{H} + 1}\right]$$

$$= \cos^{-1}\left[\frac{1}{\frac{(100)(101.5)}{235000} + 1}\right]$$

$$\underline{\theta = 16.8156^\circ}$$

$$\boxed{\theta = \tan^{-1}\left(\frac{Sw}{H}\right)}$$

$$\tan\theta = S\,\frac{w}{H}$$

$$\therefore S = \left(\frac{H}{w}\right)\tan\theta$$

$$= \frac{235000}{101.5}\tan 16.8156^\circ$$

$$\underline{\underline{S = 673.3 \text{ ft}}}$$

90 ft/shot = 7.48 shots

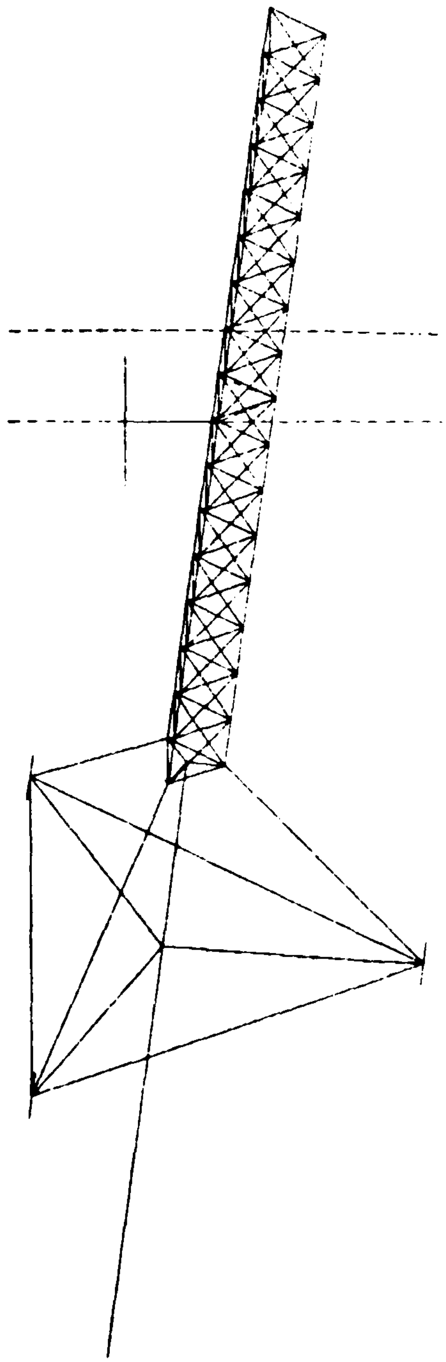
$\boxed{\text{SAY 8 shots/leg}}$



GPO 942-951

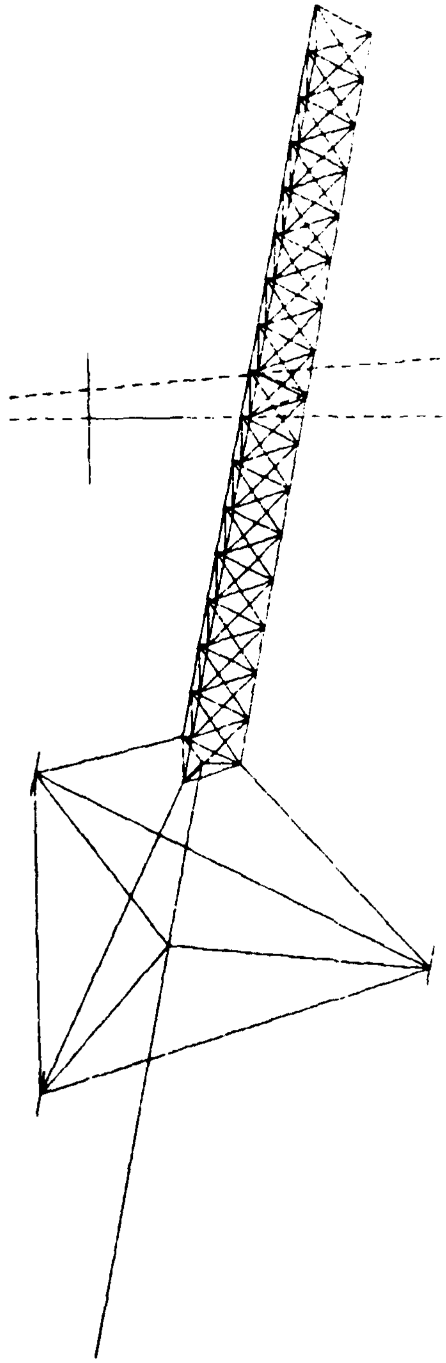
# C

APPENDIX C

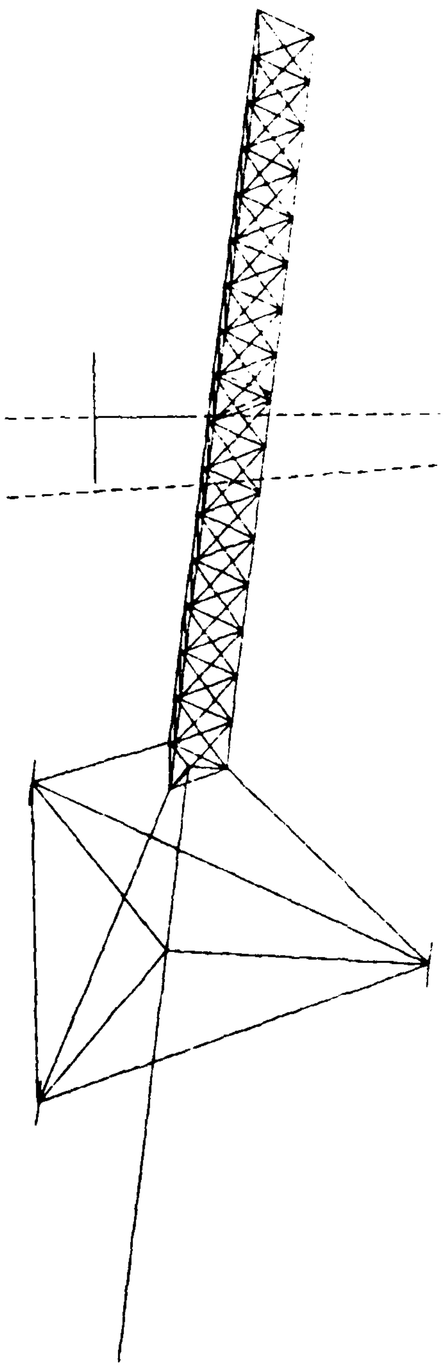


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 2.0

PLOT 1 (PAPER SIZE 7.4 X 4.8)

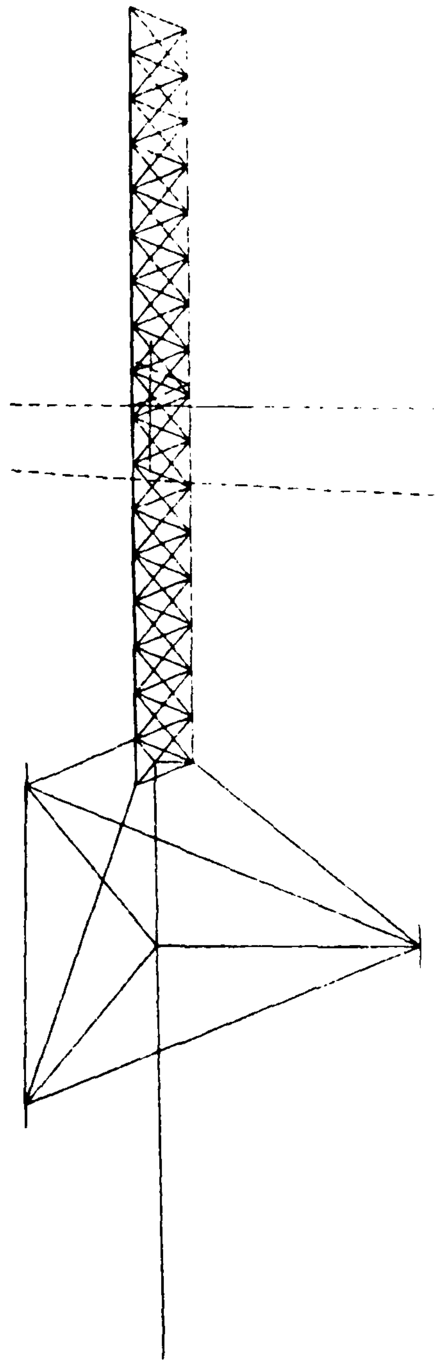


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 2.72



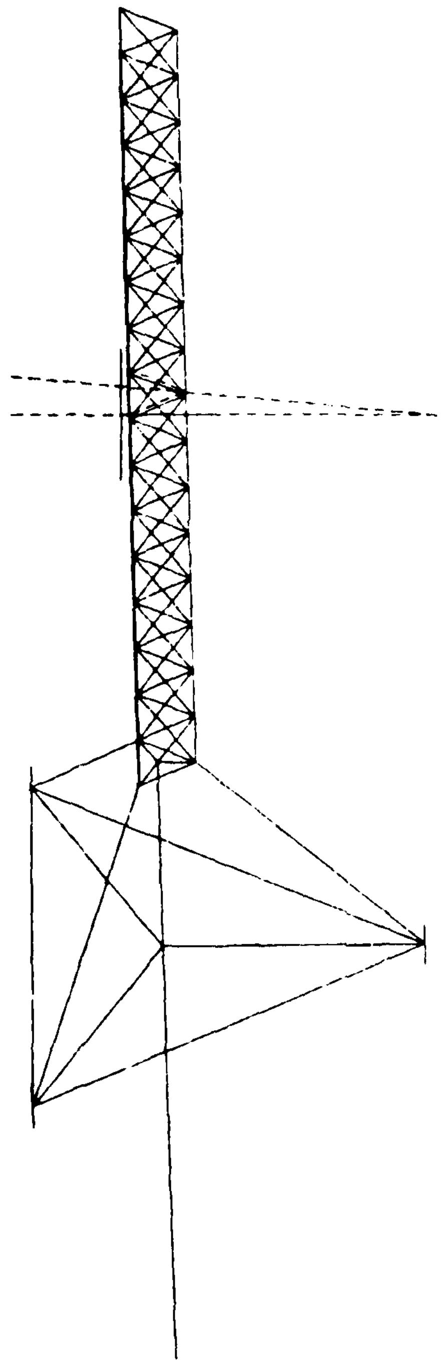
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS:   AT TIME = 5.44

PLOT 3 PAPER SIZE 7.4 X 4.81



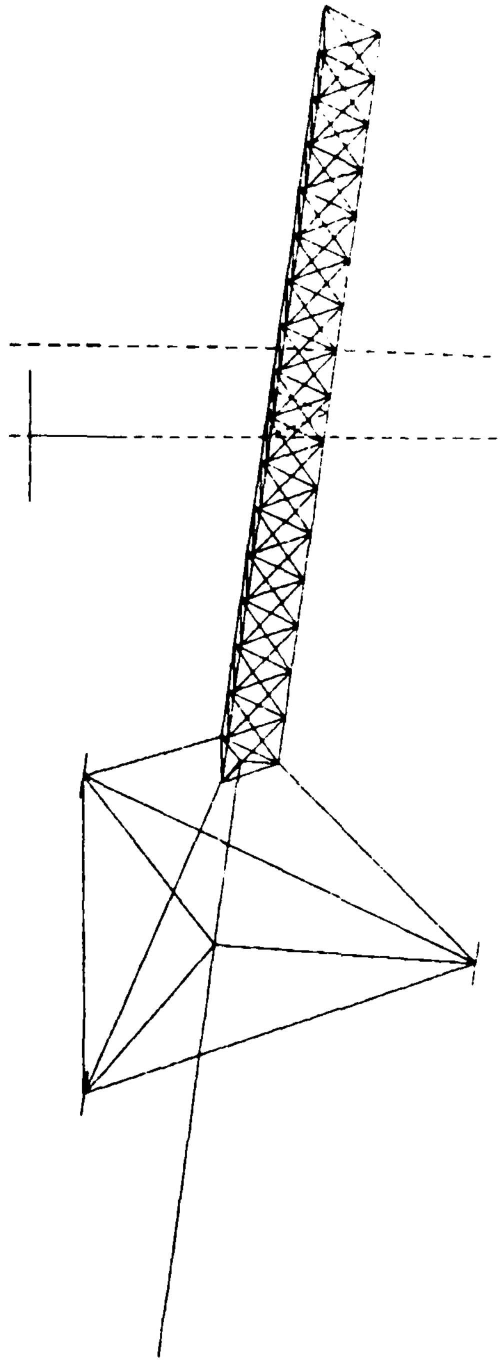
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 8.16

PLOT 4 (PAPER SIZE 7.4 X 9.0)



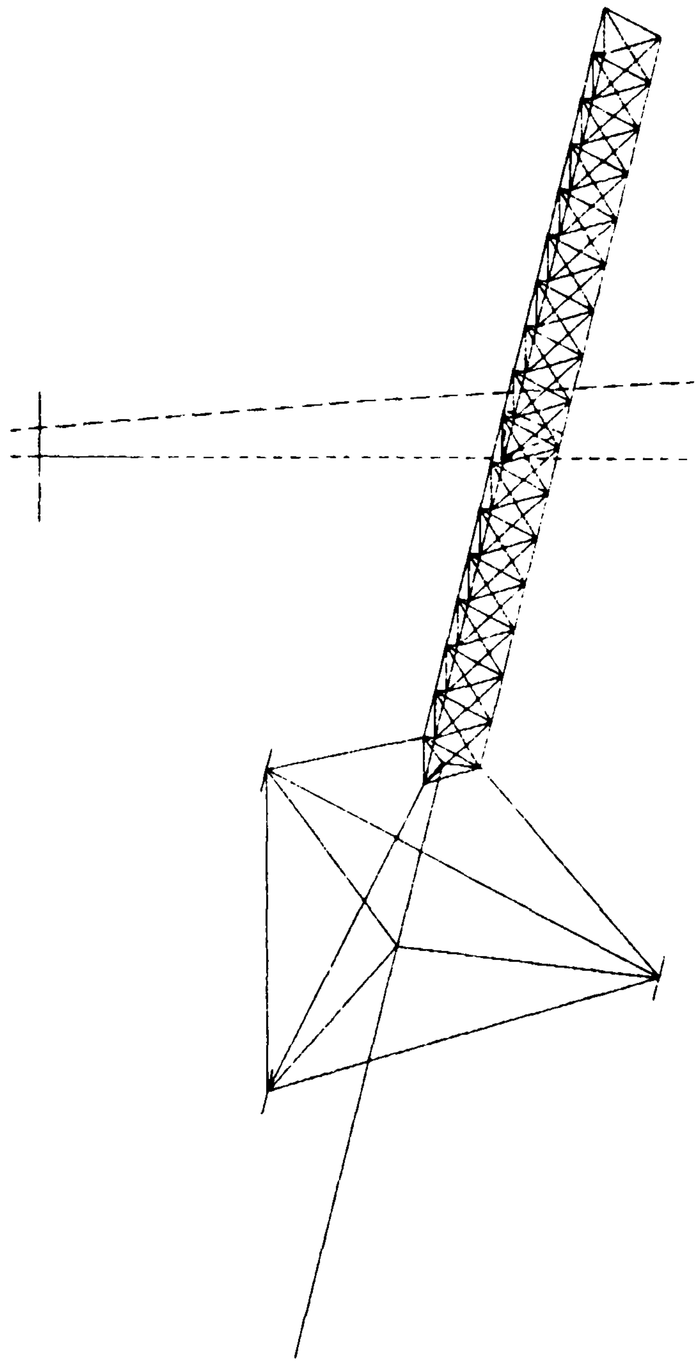
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS: AT TIME = 10.66

PLOT 5 (PAPER SIZE 7.4 X 4.8)



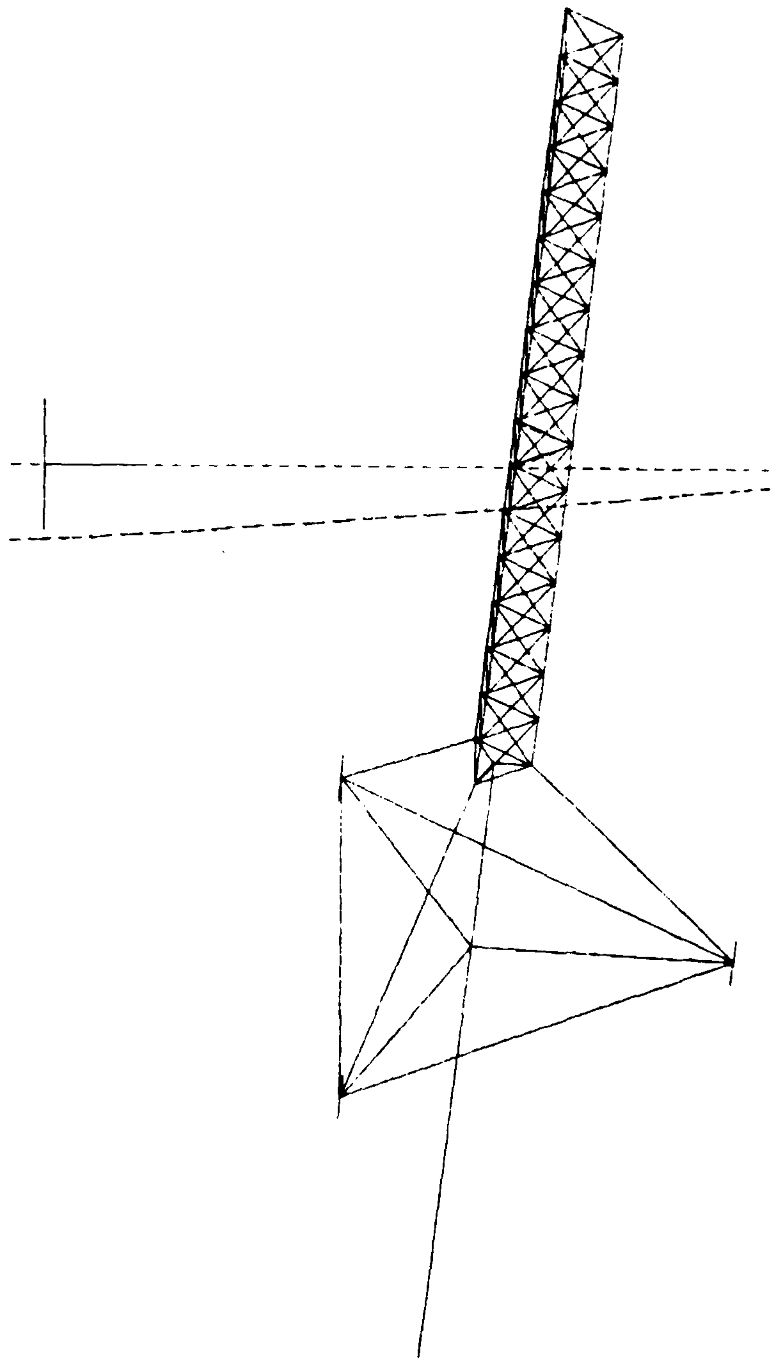
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 13.62

PLOT 8 (PAPER SIZE 7.4 X 4.8)



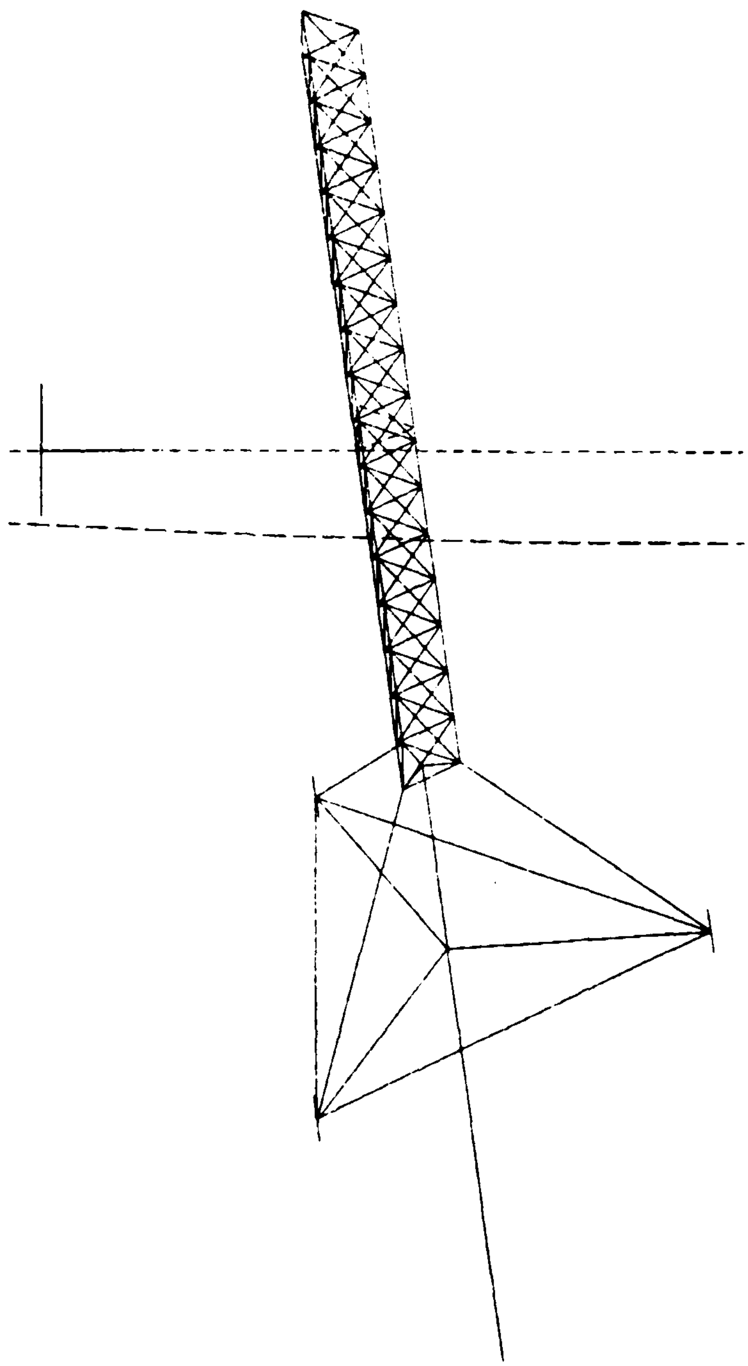
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 16.32

PLOT 7 (PAPER SIZE 7.4 X 4.8)

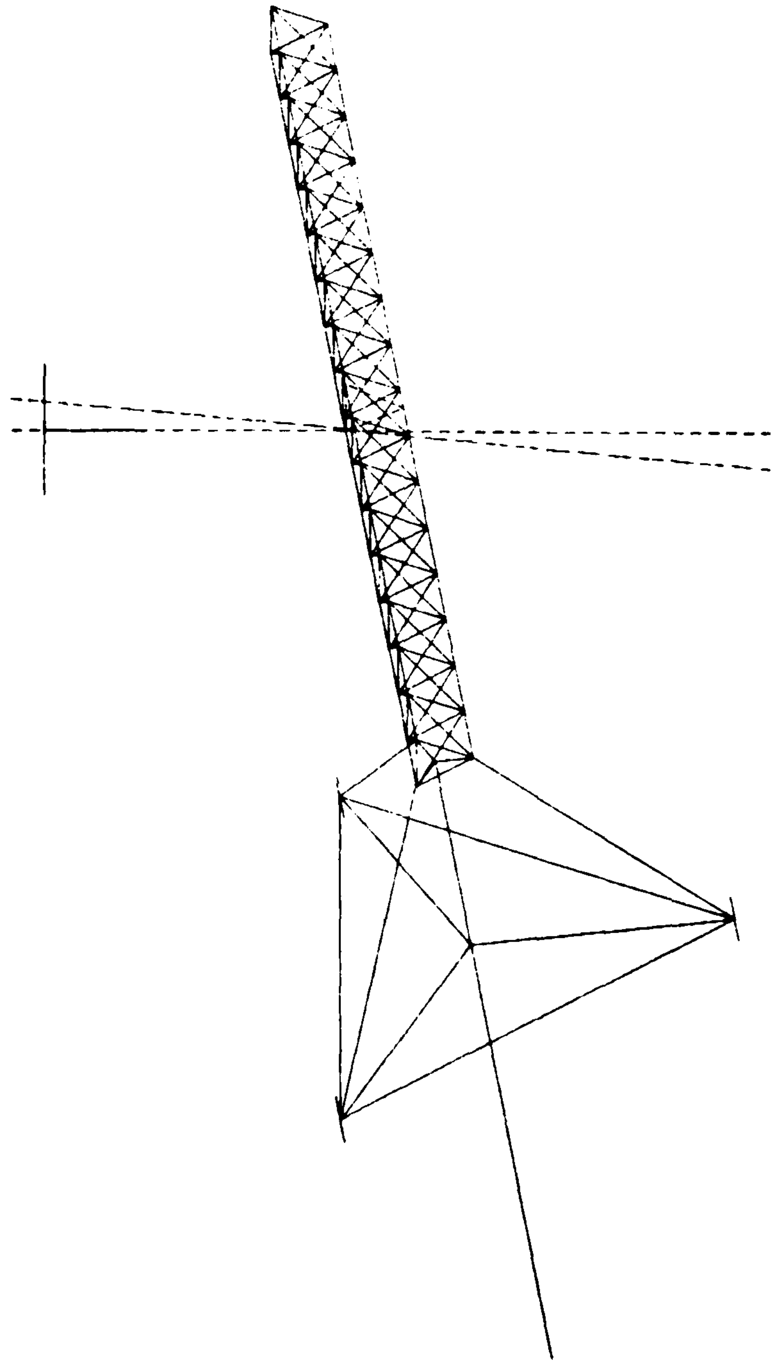


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS:   AT TIME = 19.04

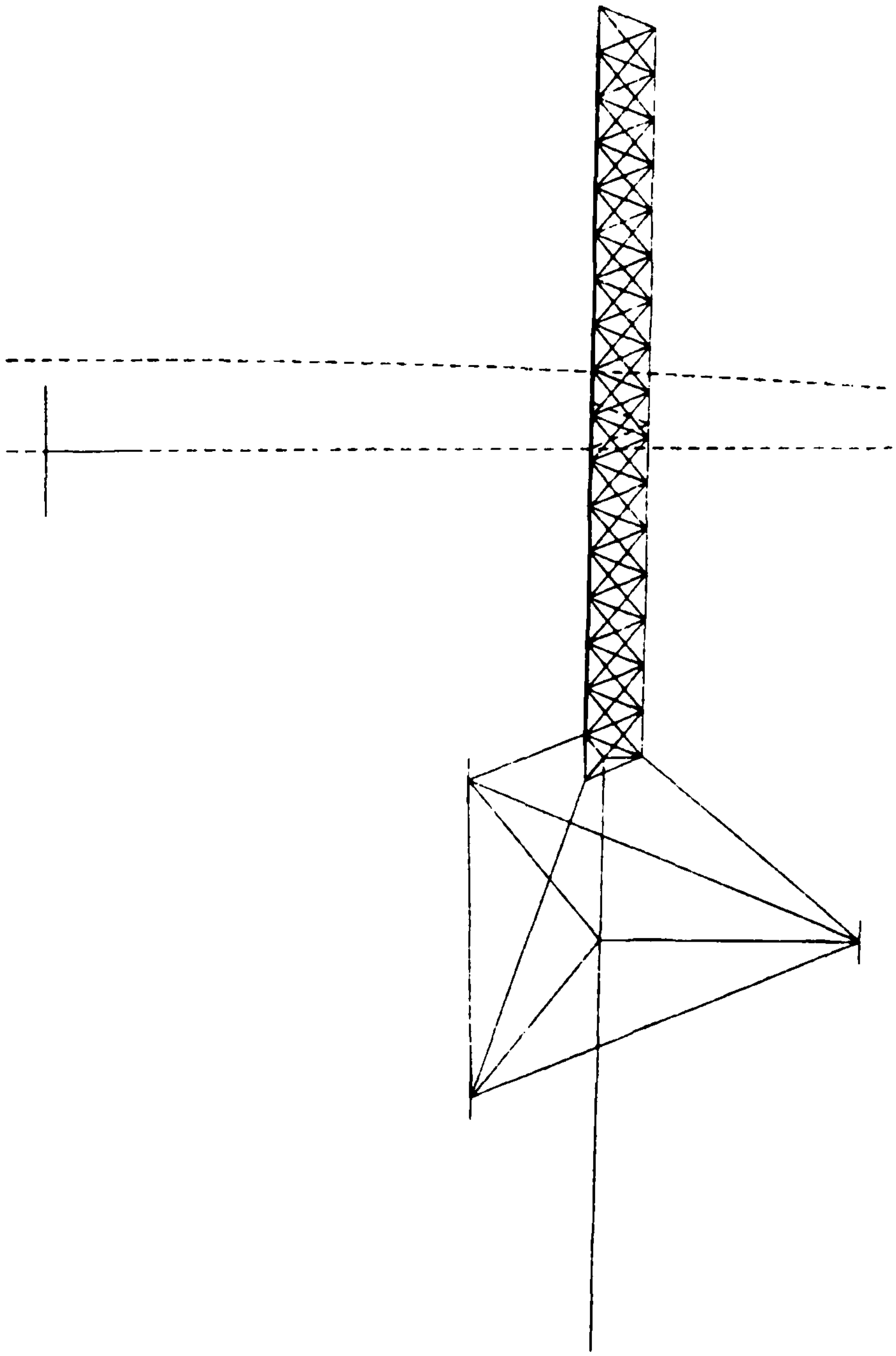
PLOT 8 (PAPER SIZE 7.4 X 9.8)



BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 21.76

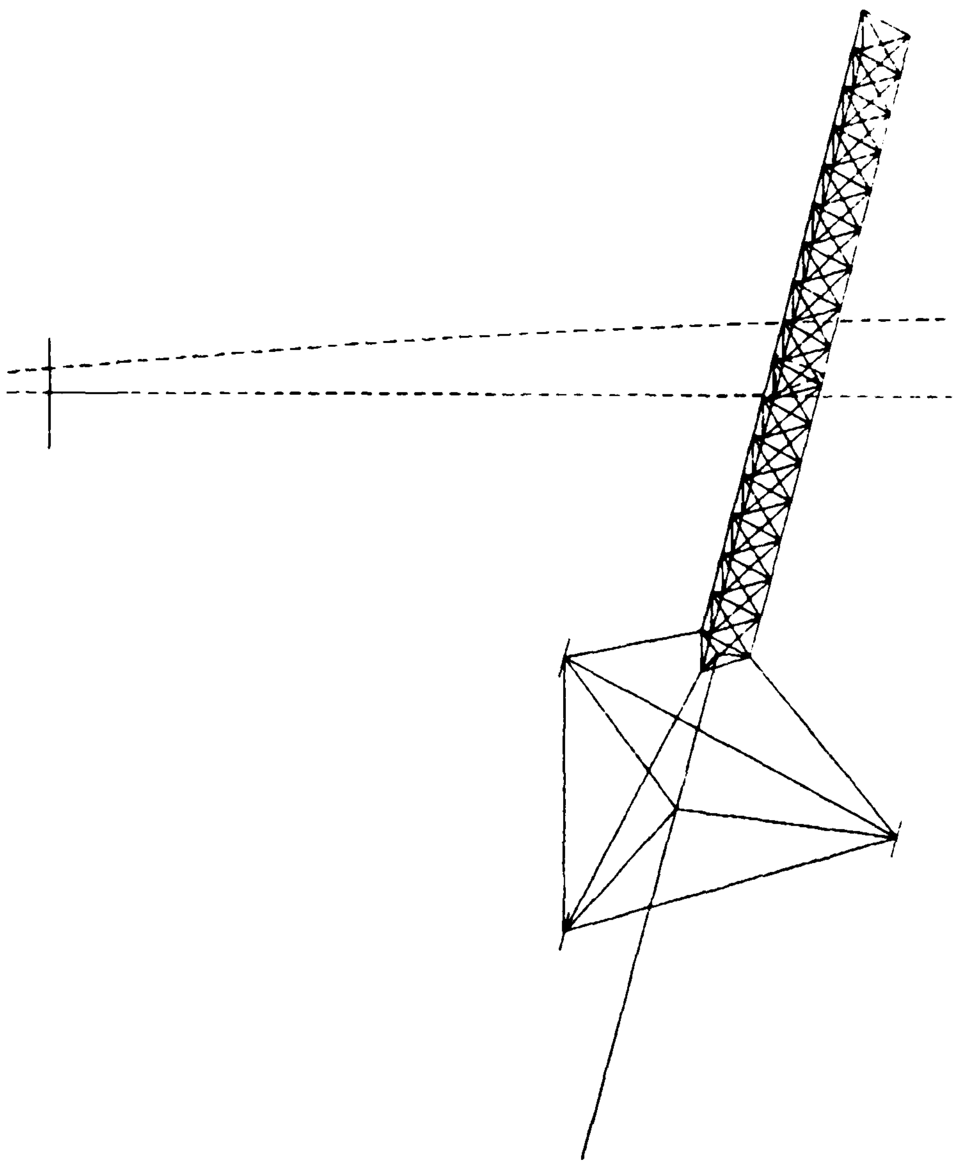


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  24.48



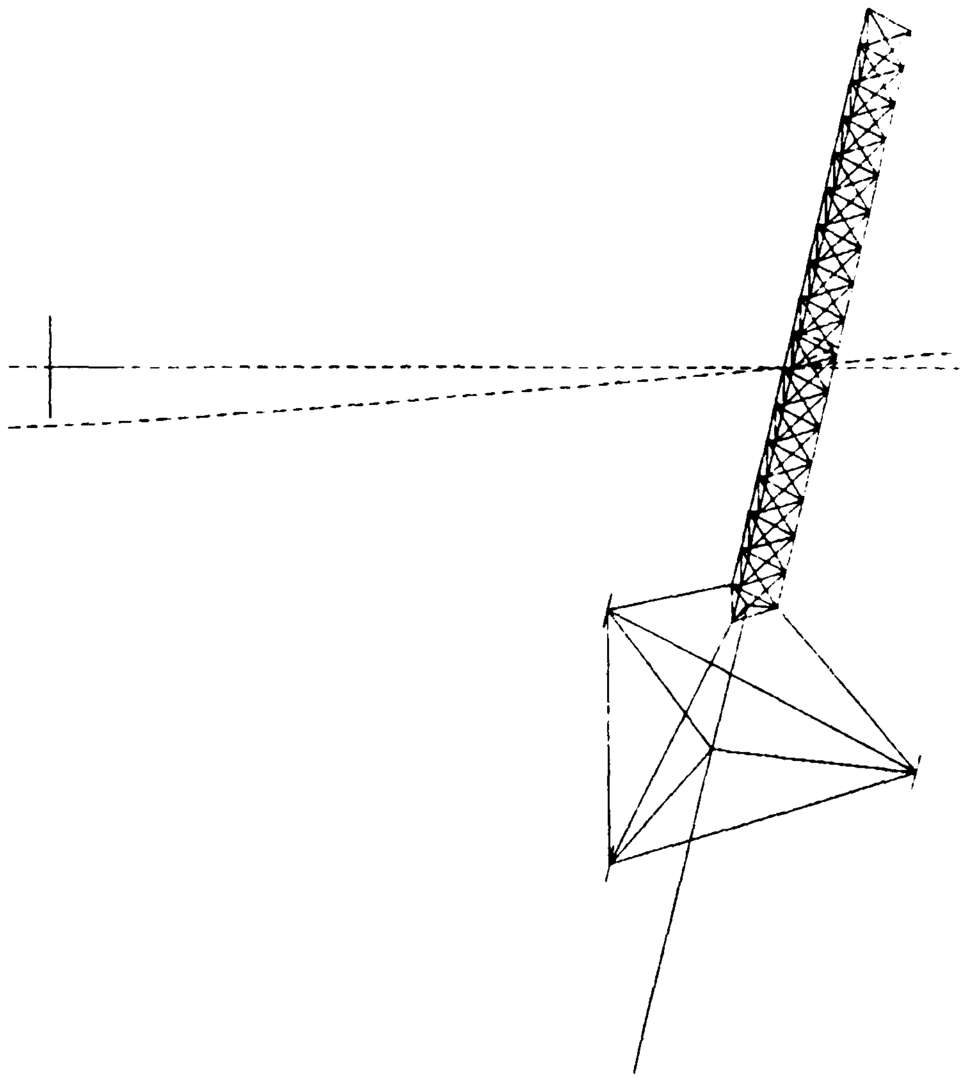
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 27.27

PLOT 10 (PAPER SIZE 7.4 X 5.0)



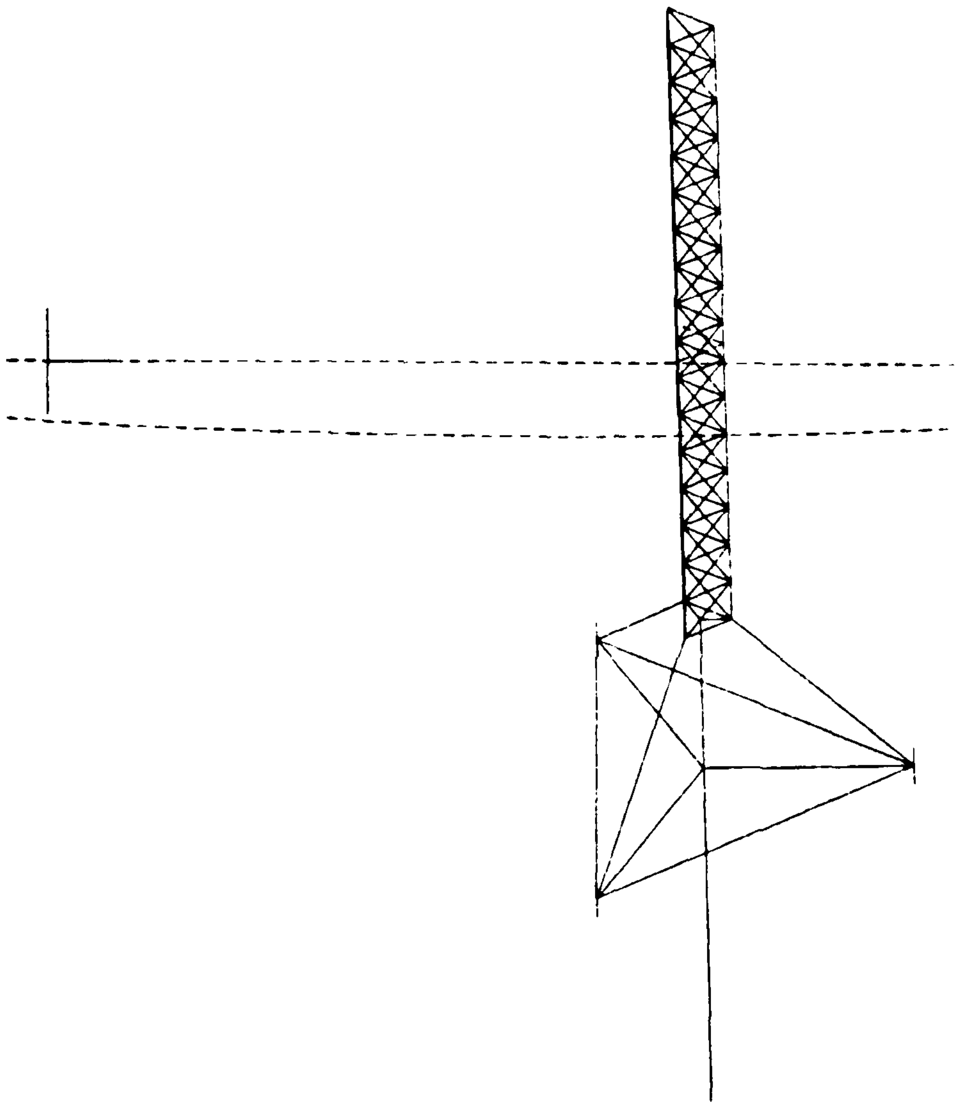
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  29.92

PLOT 12 (PAPER SIZE 7.4 X 8.1)



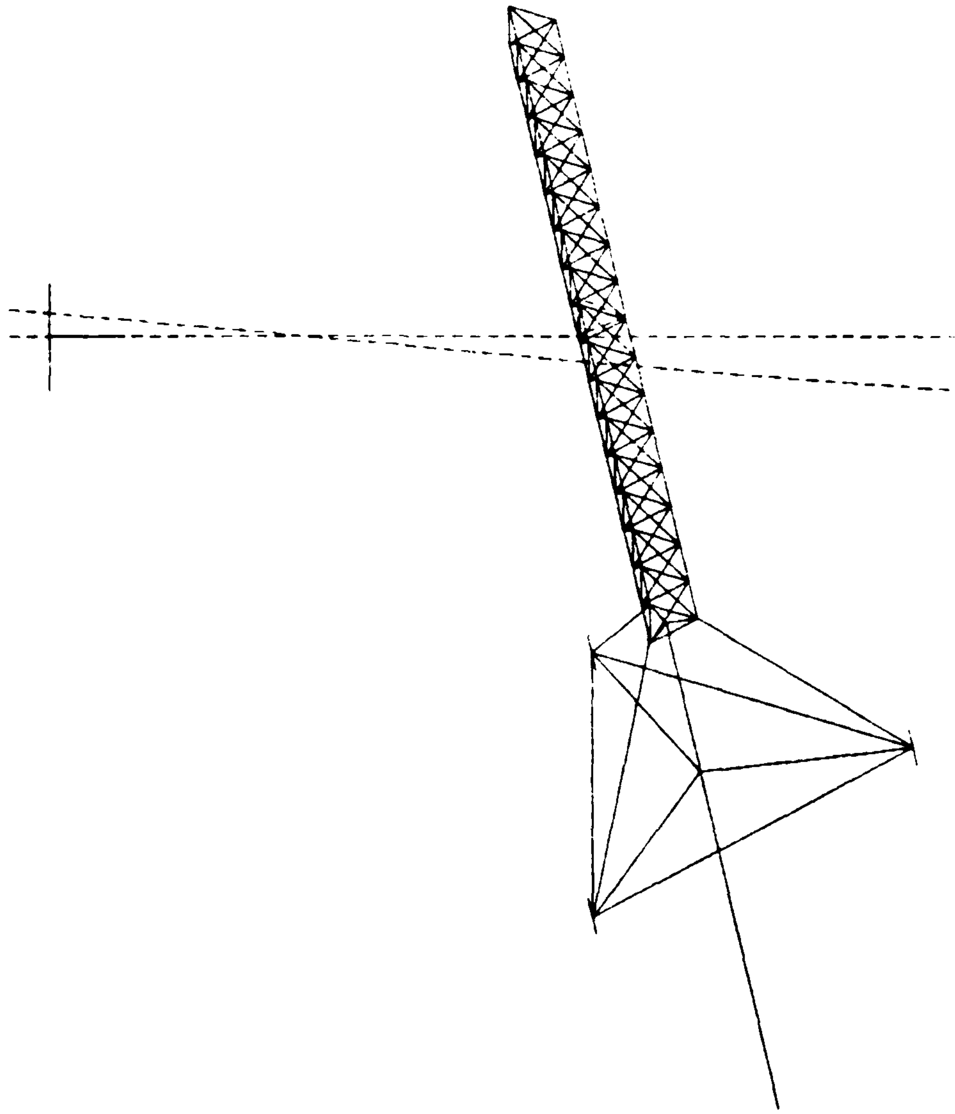
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 32.64

PLOT 13 (PAPER SIZE 7.4 X 8.8)



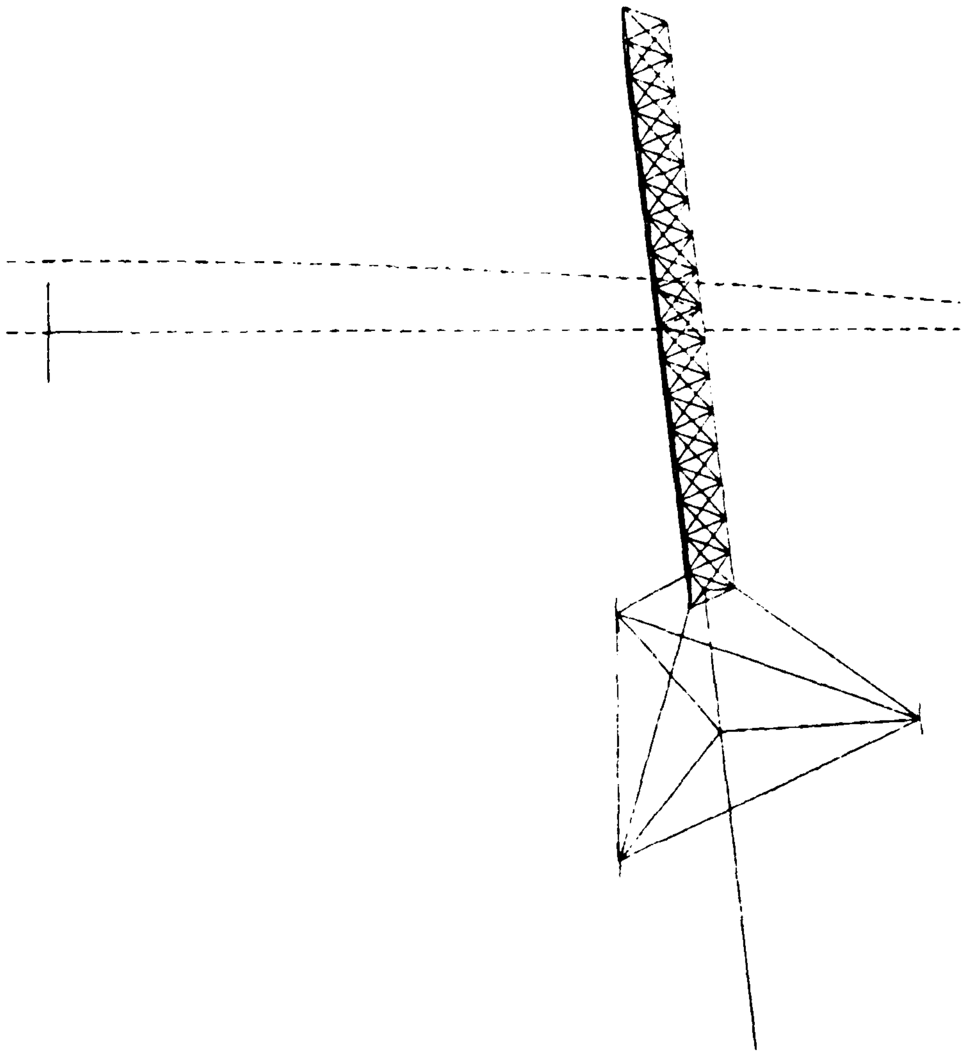
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1   AT TIME =  35.36

PLOT 14 (PAPER SIZE 7.4 X 8.4)



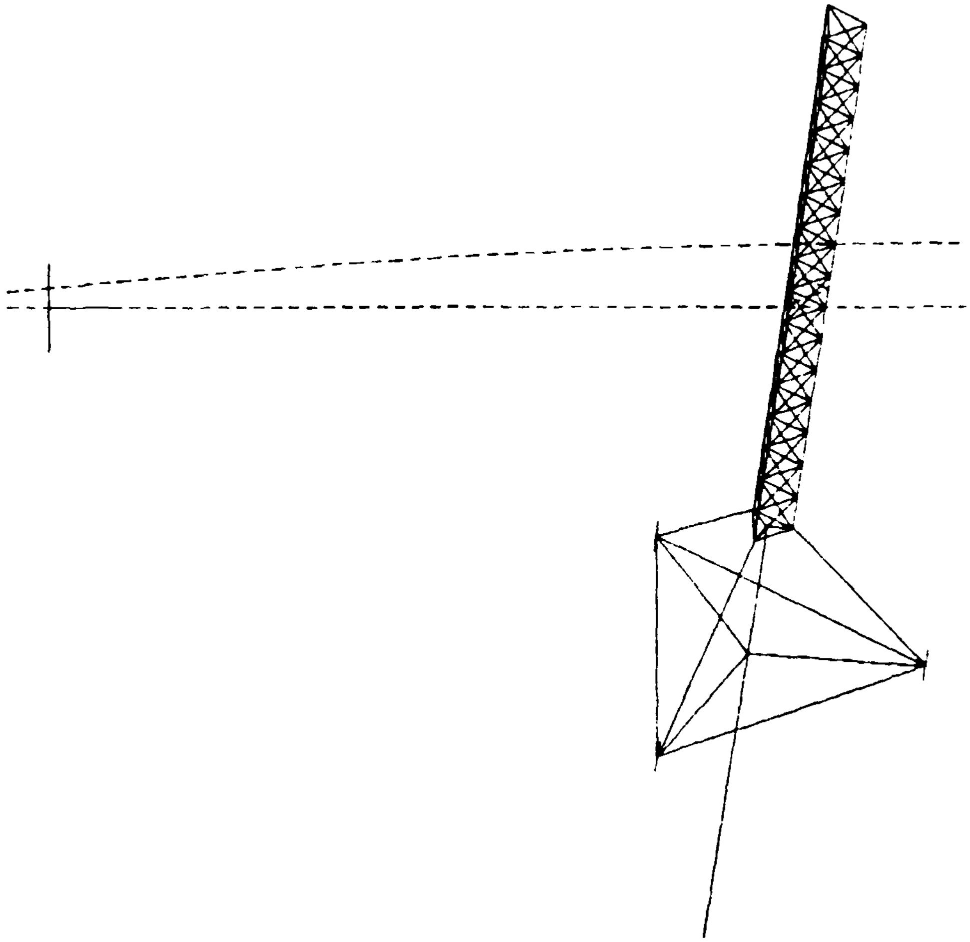
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  38.08

PLOT IS (PAPER SIZE 7.4 X 8.4)



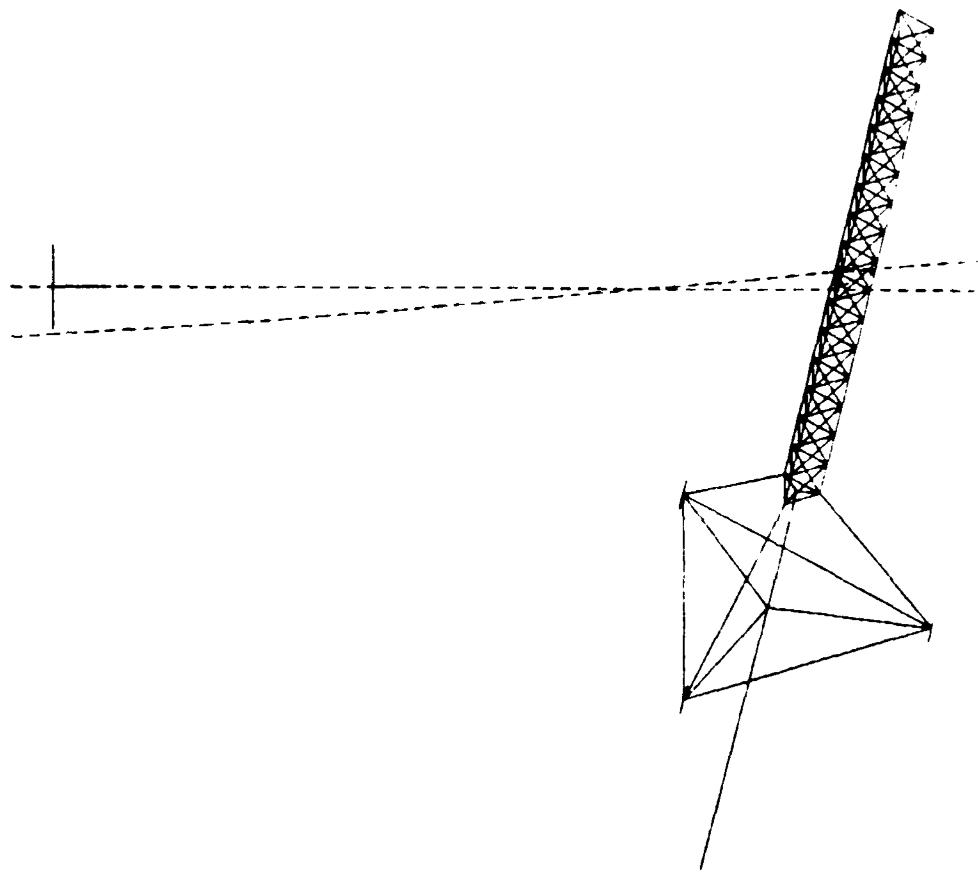
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 40.80

PLOT 16 (PAPER SIZE 7.4 X 8.7)



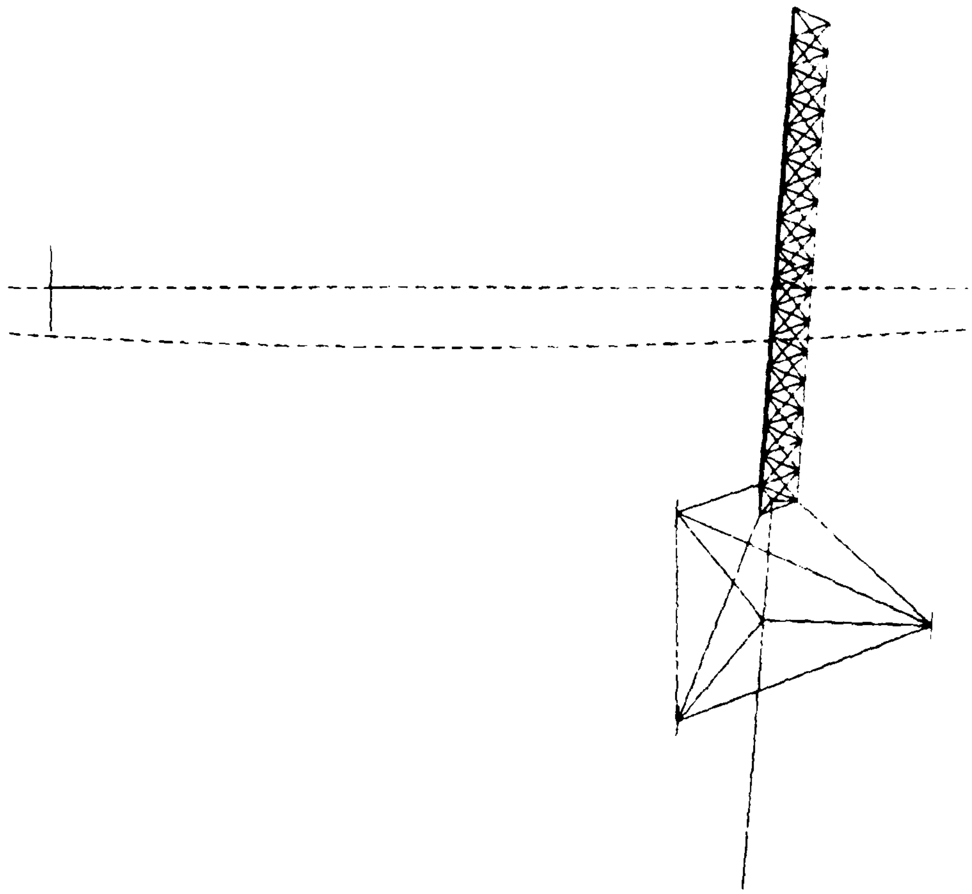
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 43.52

PLOT 17 (PAPER SIZE 7.4 X 7.5)



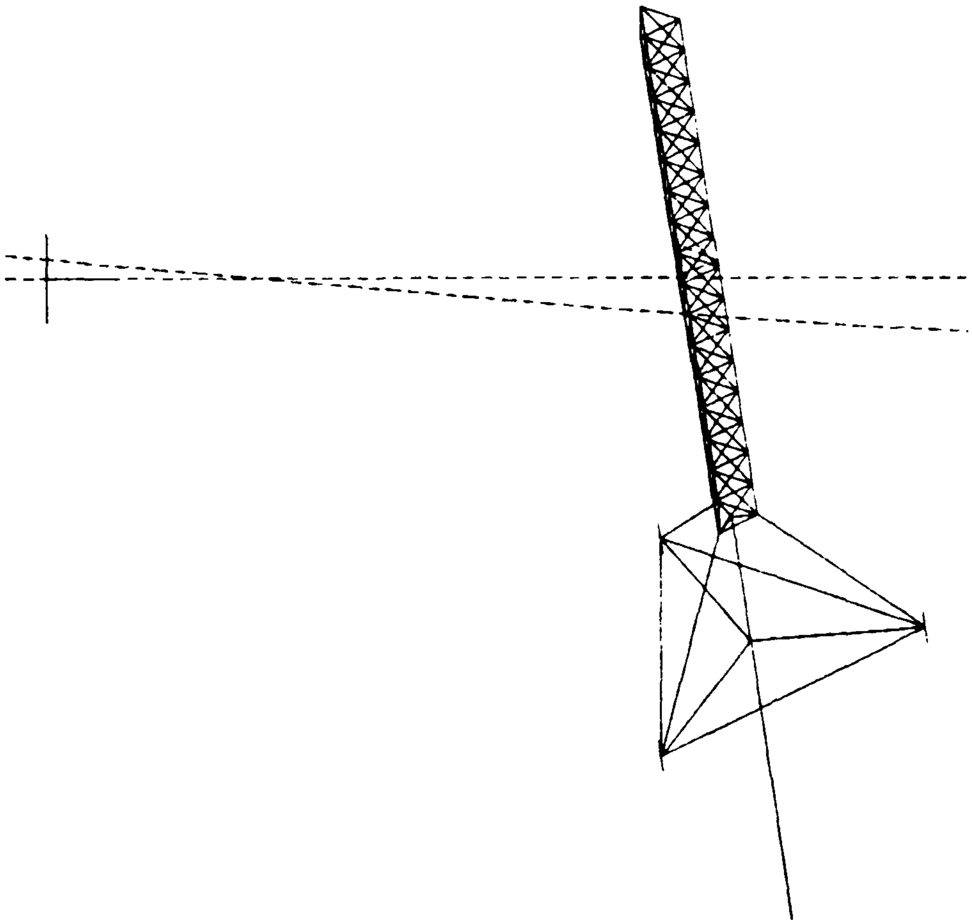
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 46.24

PLOT 10 (PAPER SIZE 7.4 X 8.2)



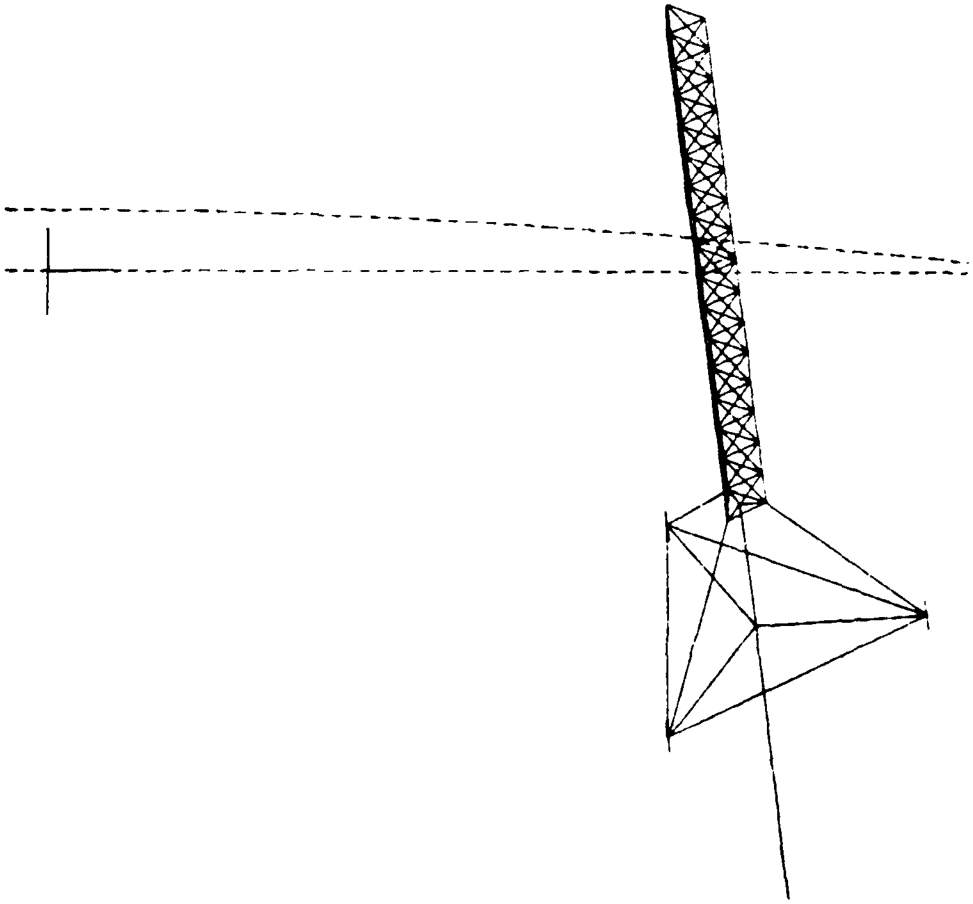
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 48.96

PLOT 19 (PAPER SIZE 7.4 X 8.0)

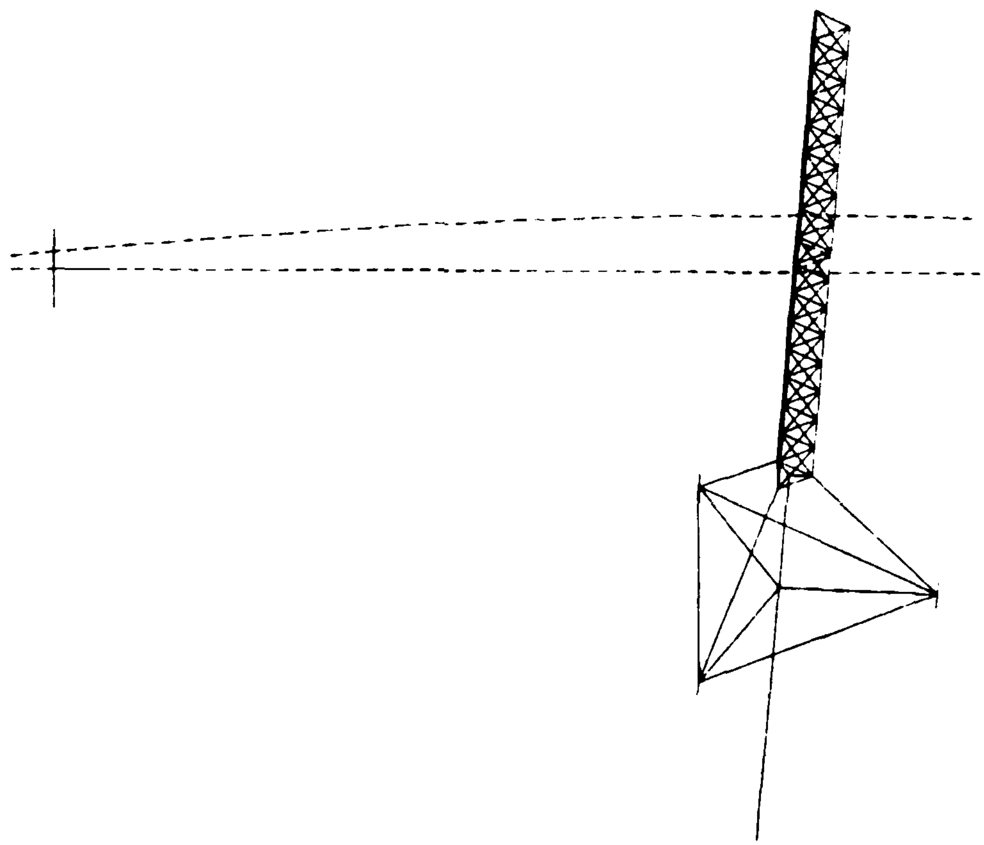


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  51.68

PLOT 20 (PAPER SIZE 7.4 X 7.7)

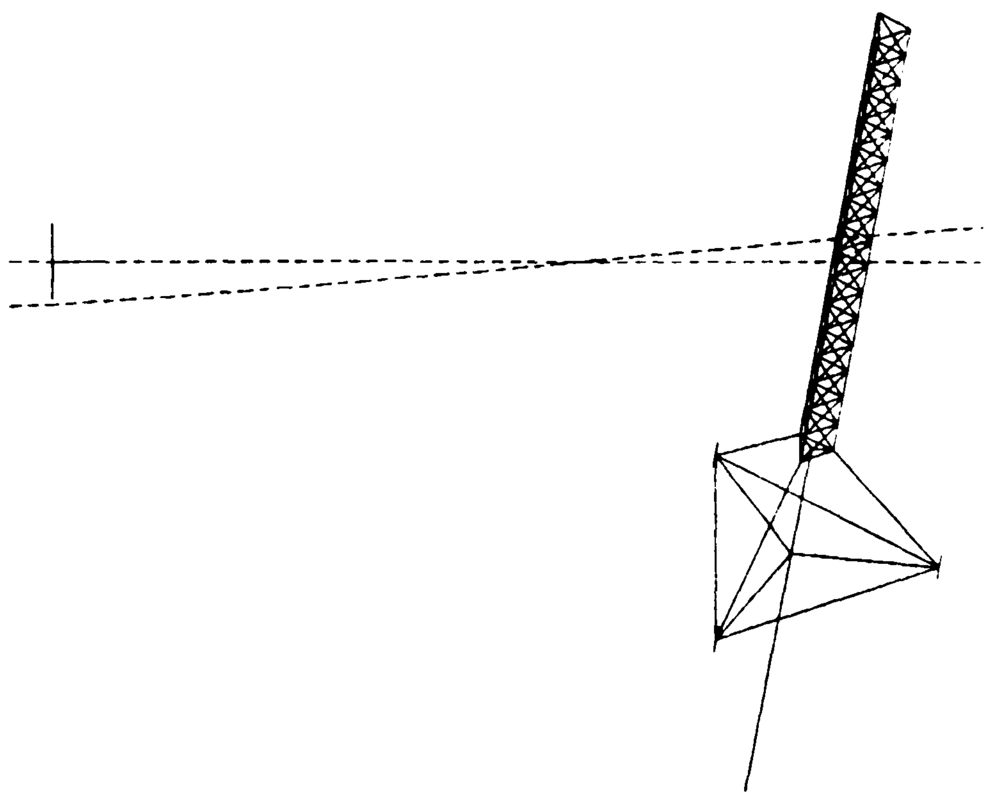


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 54.40



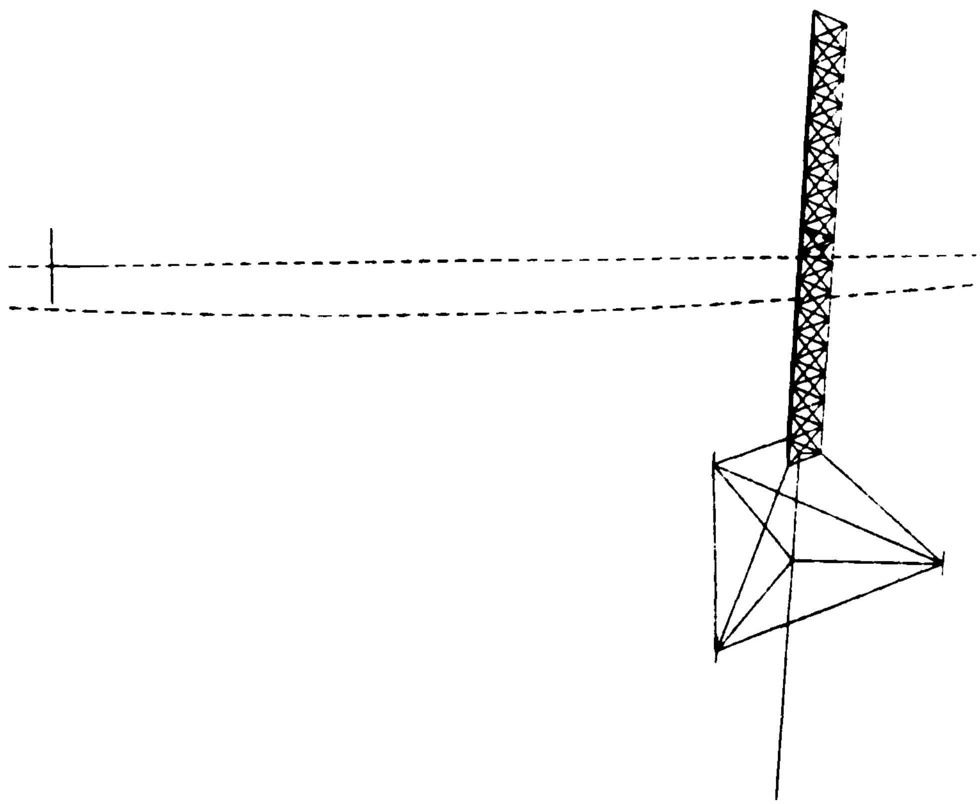
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 57.12

PLOT 22 (PAPER SIZE 7.4 X 8.5)



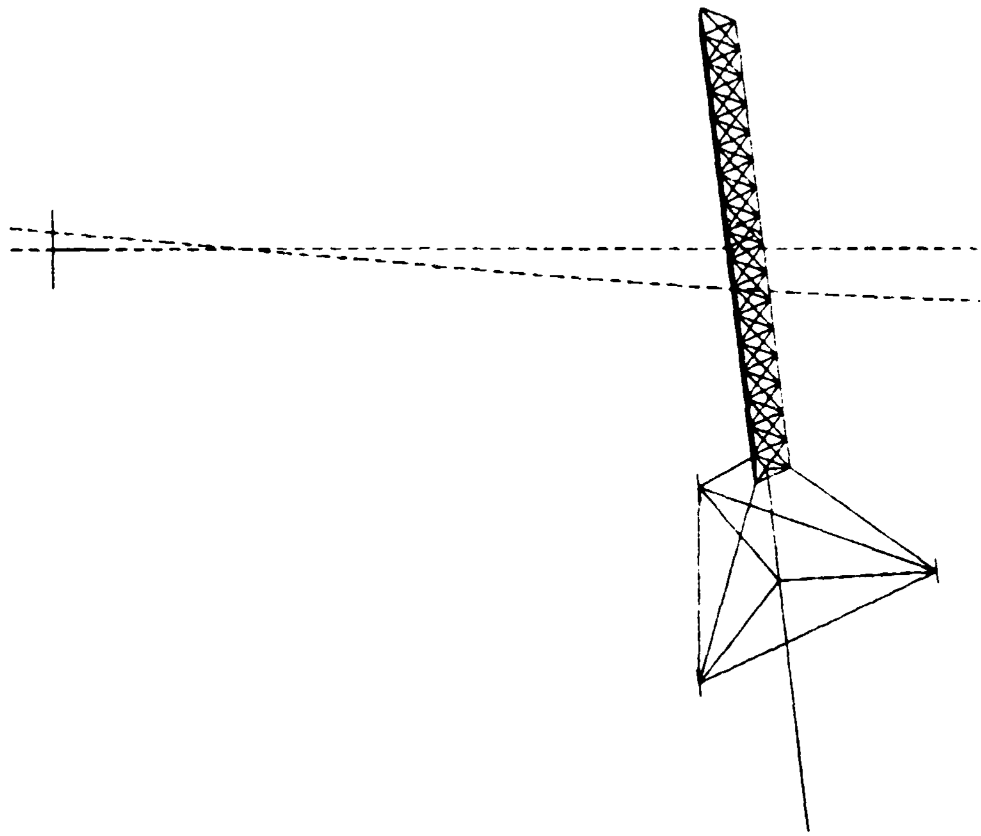
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 59.84

PLOT 23 (PAPER SIZE 7.4 x 8.0)



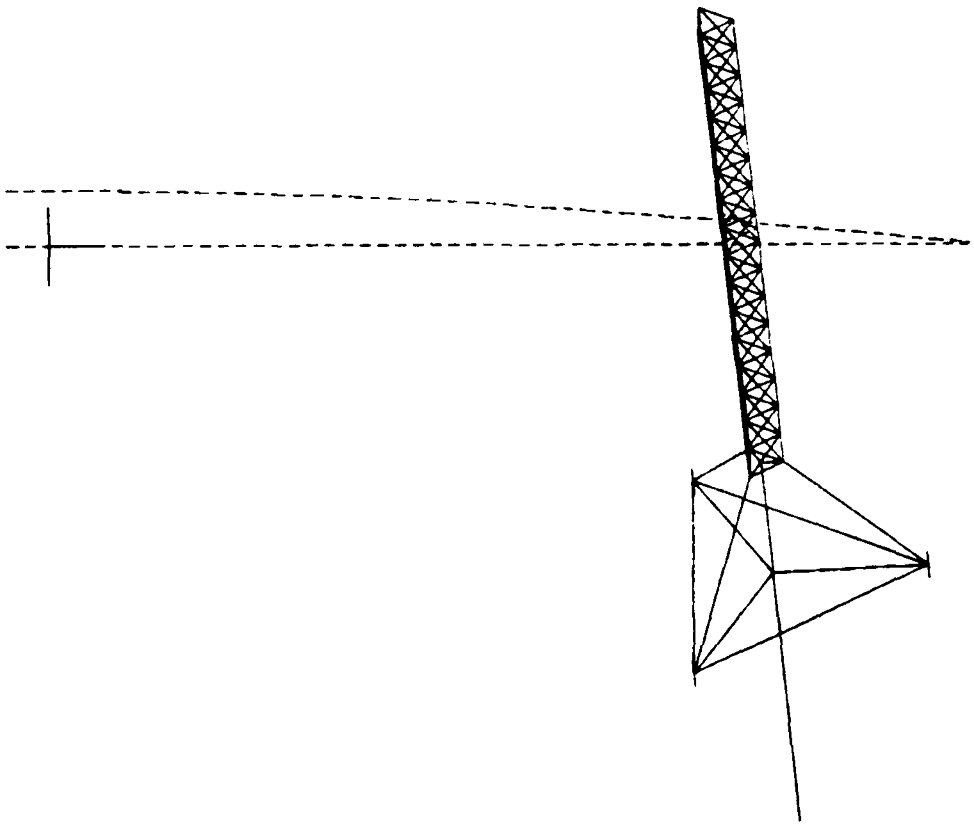
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  62.56

PLOT 24 (PAPER SIZE 7.4 X 8.0)



BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 65.28

PLOT 25 (PAPER SIZE 7.4 X 8.5)

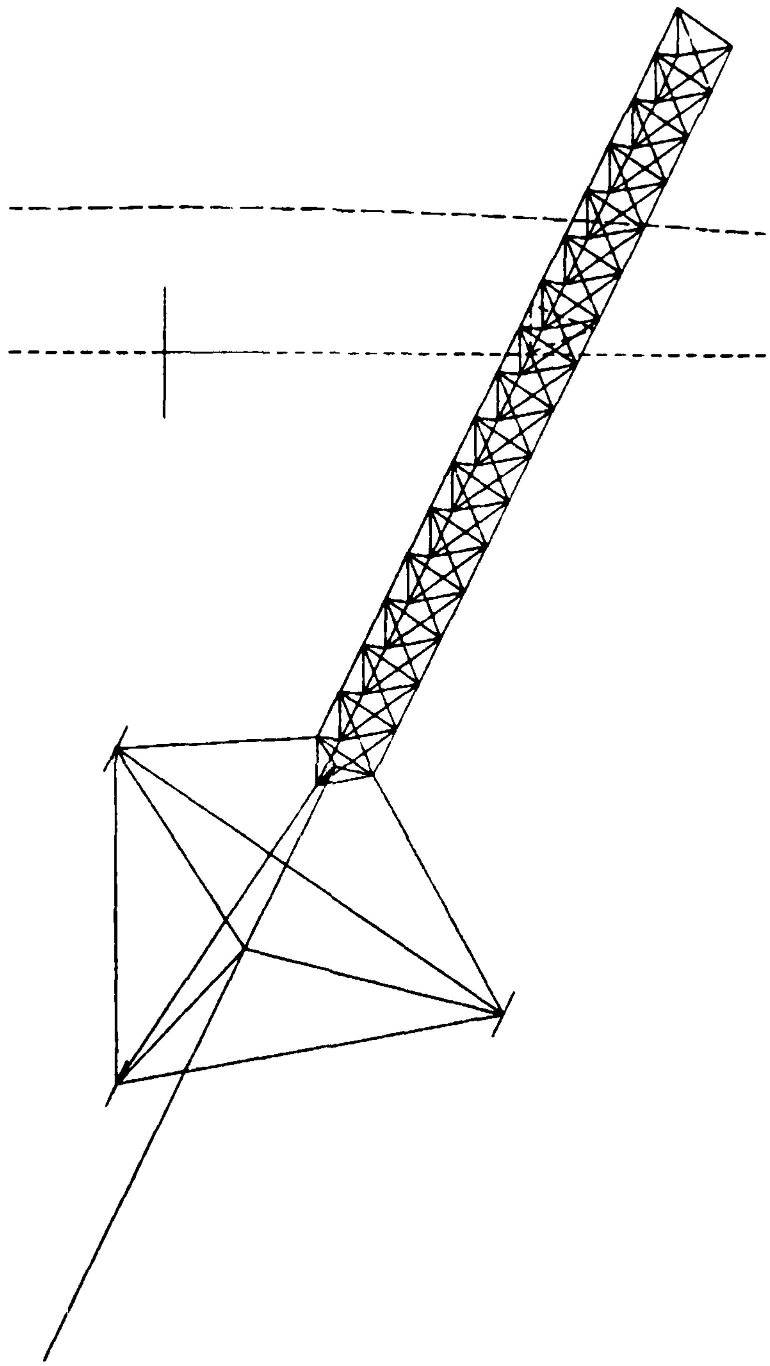


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =   68.00

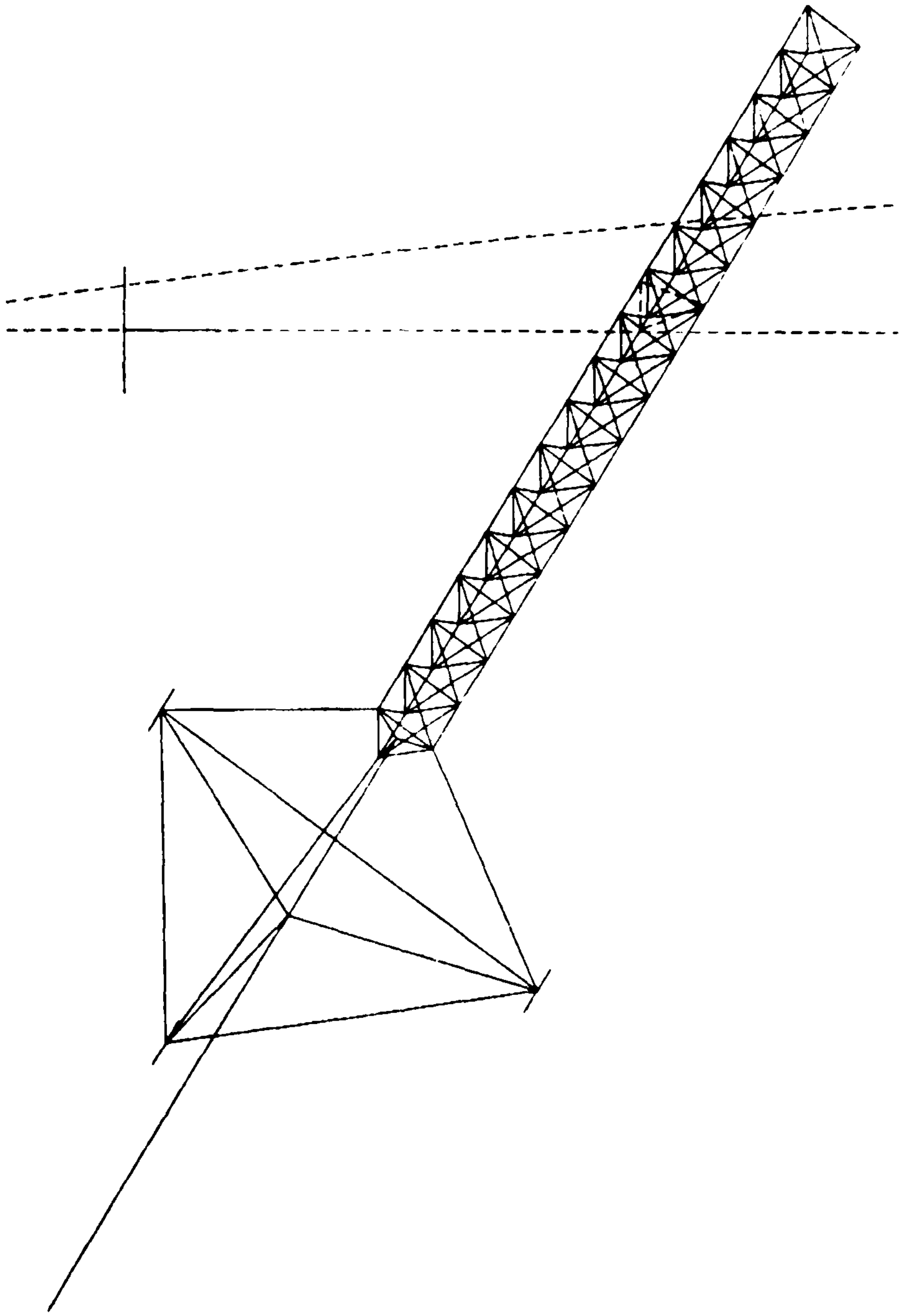
PLOT 20 (PAPER SIZE 7.4 X 8.6)

D

APPENDIX D

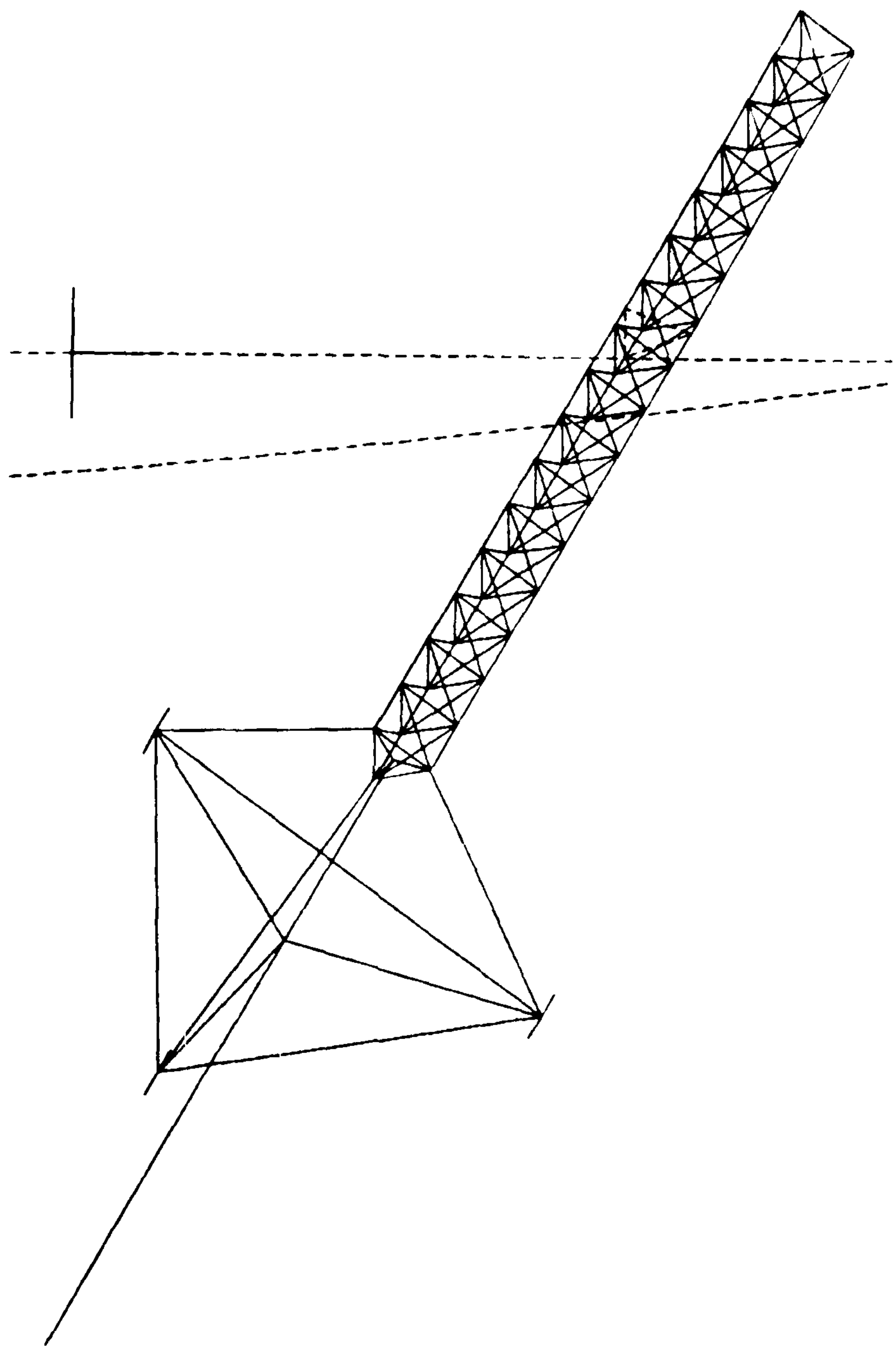


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 0.0



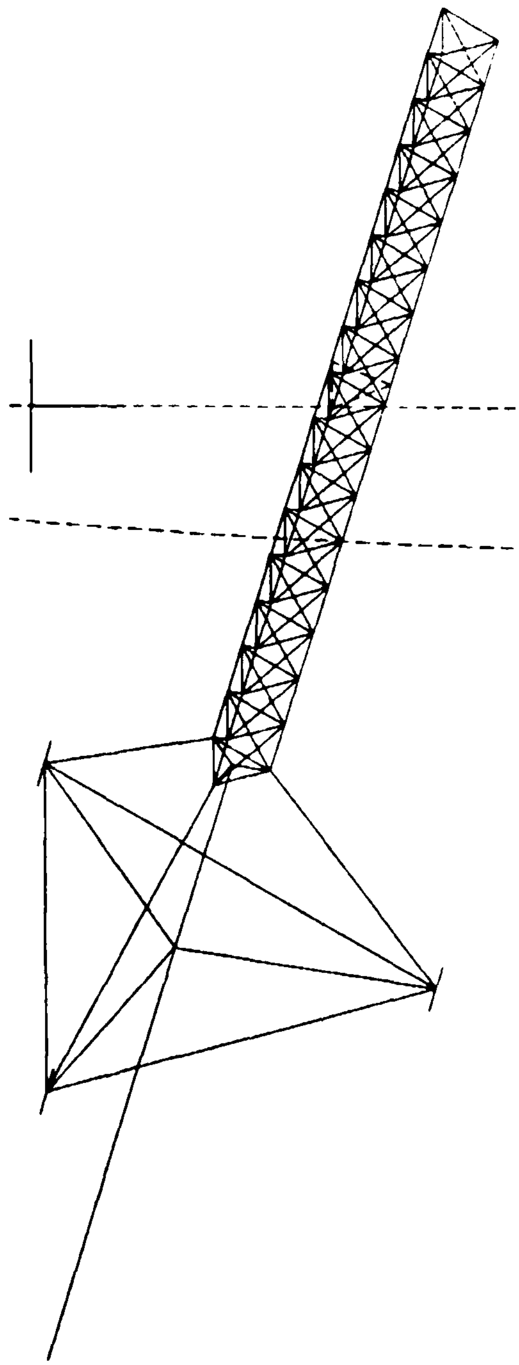
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 2.72

PLOT 2 (PAPER SIZE 7.4 X 5.2)



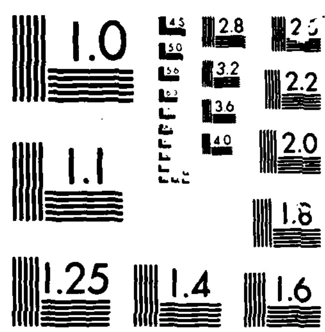
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  5.44

PLOT 3 (PAPER SIZE 7.4 X 8.1)



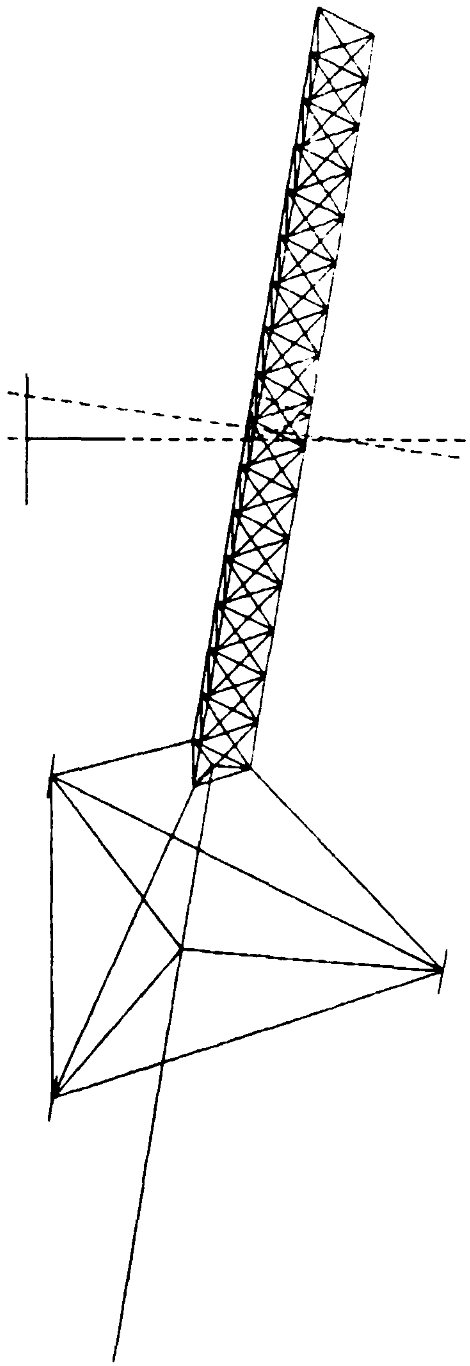
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME =  8.16

AD-A167 457 EAST COAST TACTICAL AIRCREW COMBAT TRAINING SYSTEM 2/2
FACILITY EXPANSION CON..(U) NAVAL FACILITIES
ENGINEERING COMMAND WASHINGTON DC CHESAPEAKE..
UNCLASSIFIED T J O'BOYLE SEP 81 F/G 13/10 NL

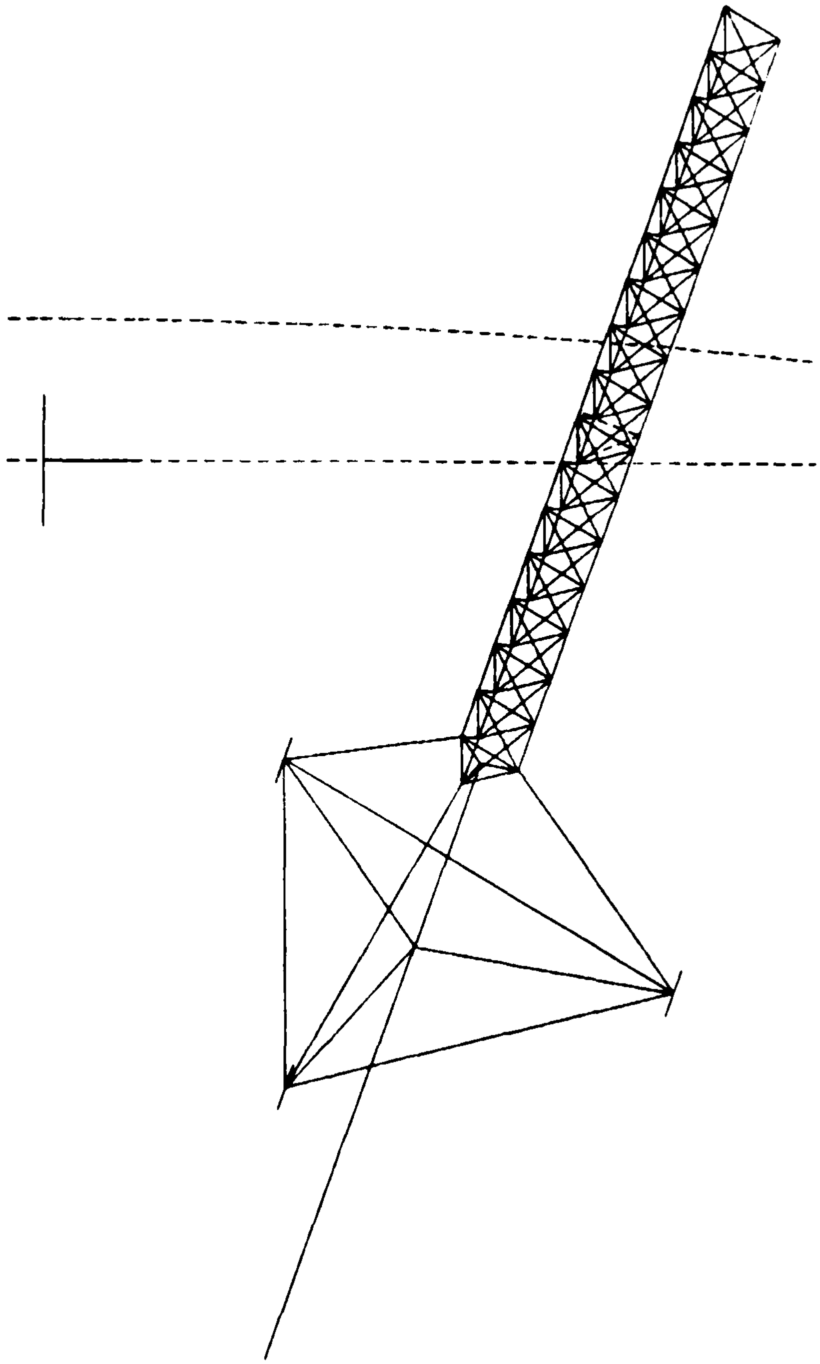



MICROCOP CHART

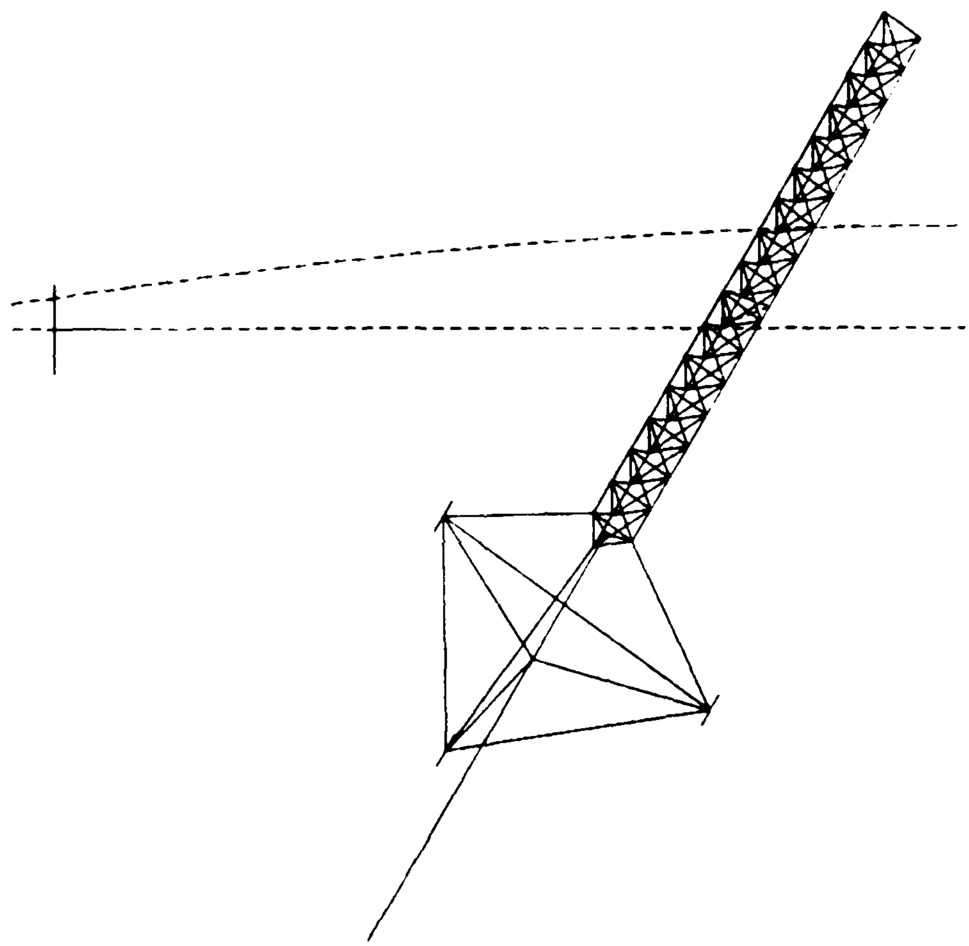
PLOT 5 (PAPER SIZE 7.4 X 9.0)



BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 10.80

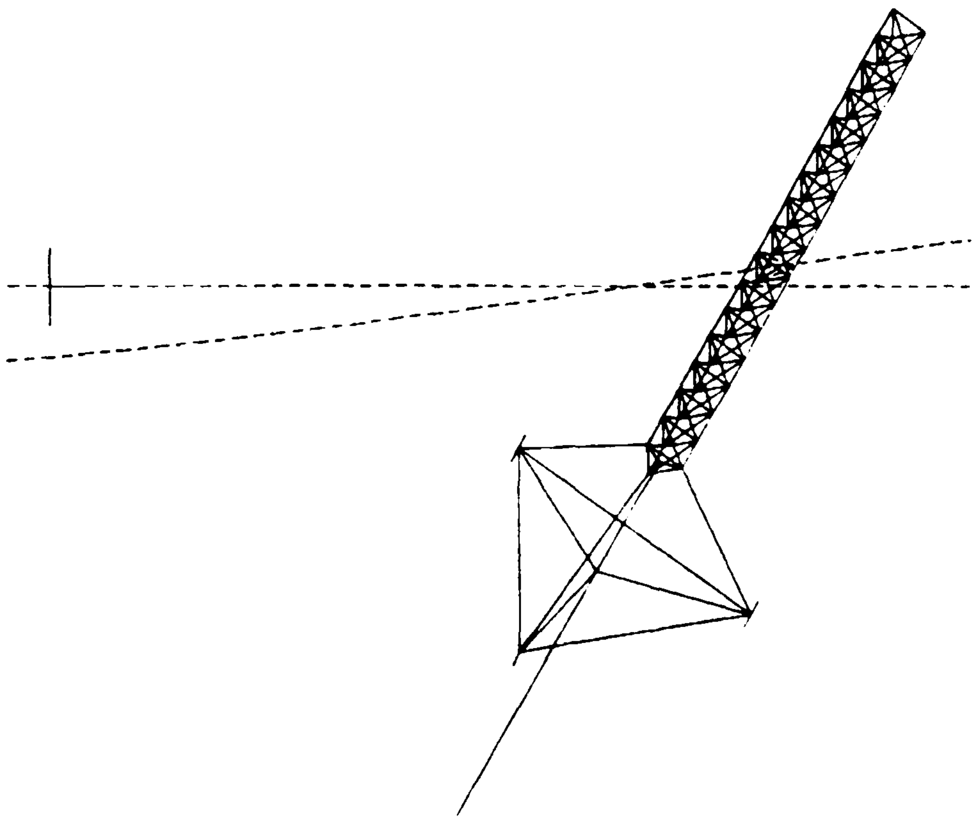


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME = 13.60



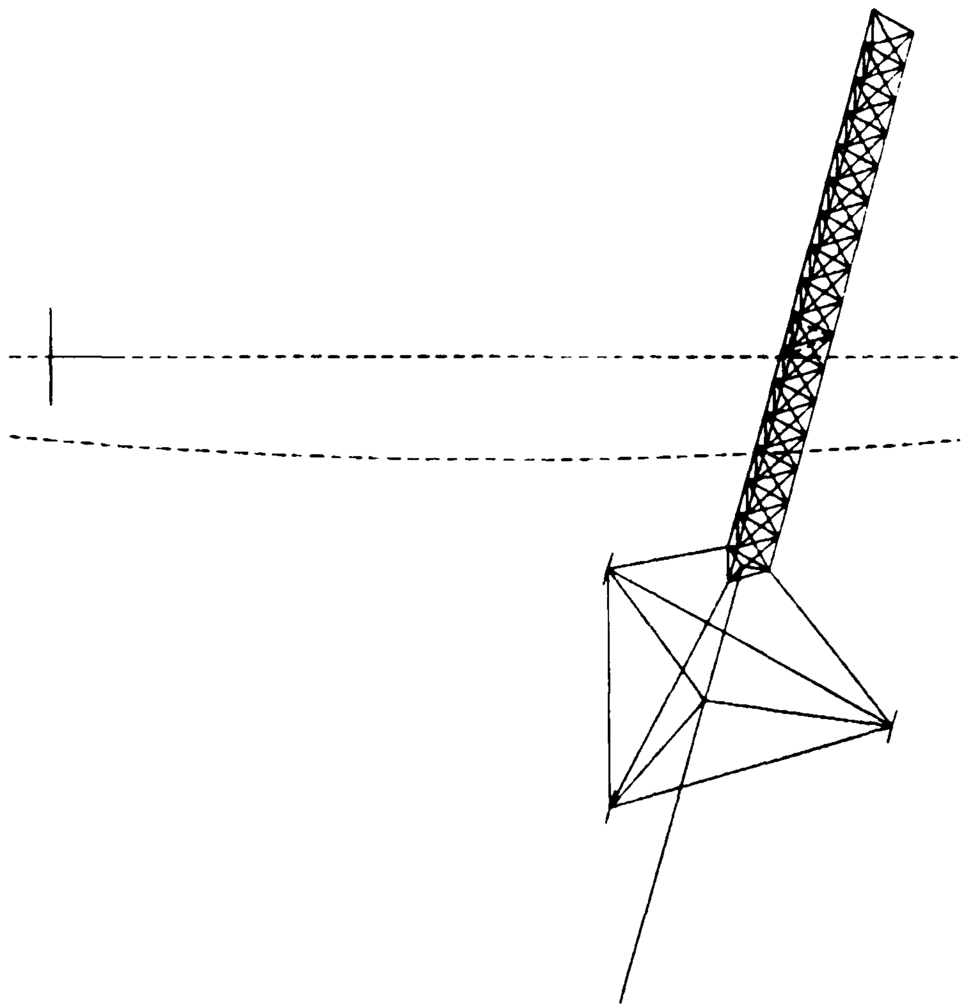
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 16.32

PLOT 7 (PAPER SIZE 7.4 X 7.8)

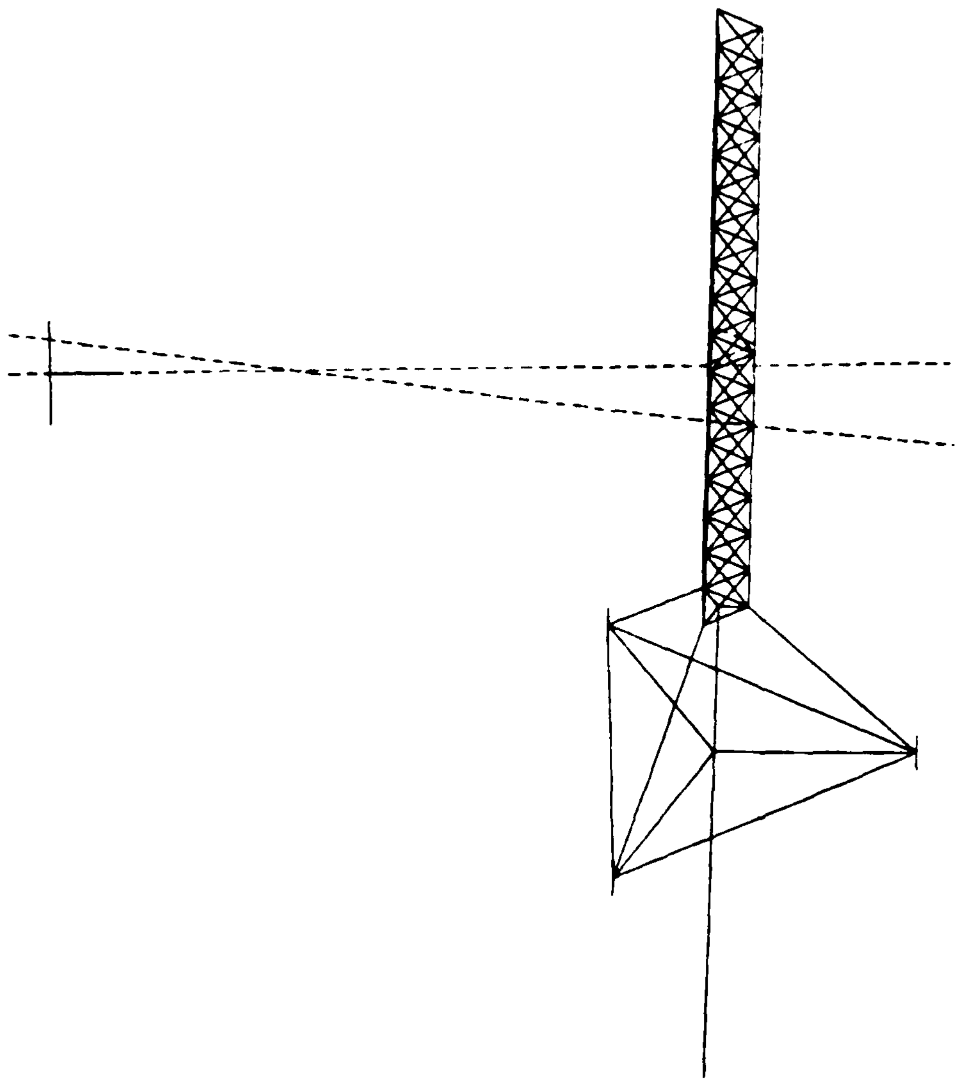


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 19.04

PLOT 8 (PAPER SIZE 7.4 X 8.7)

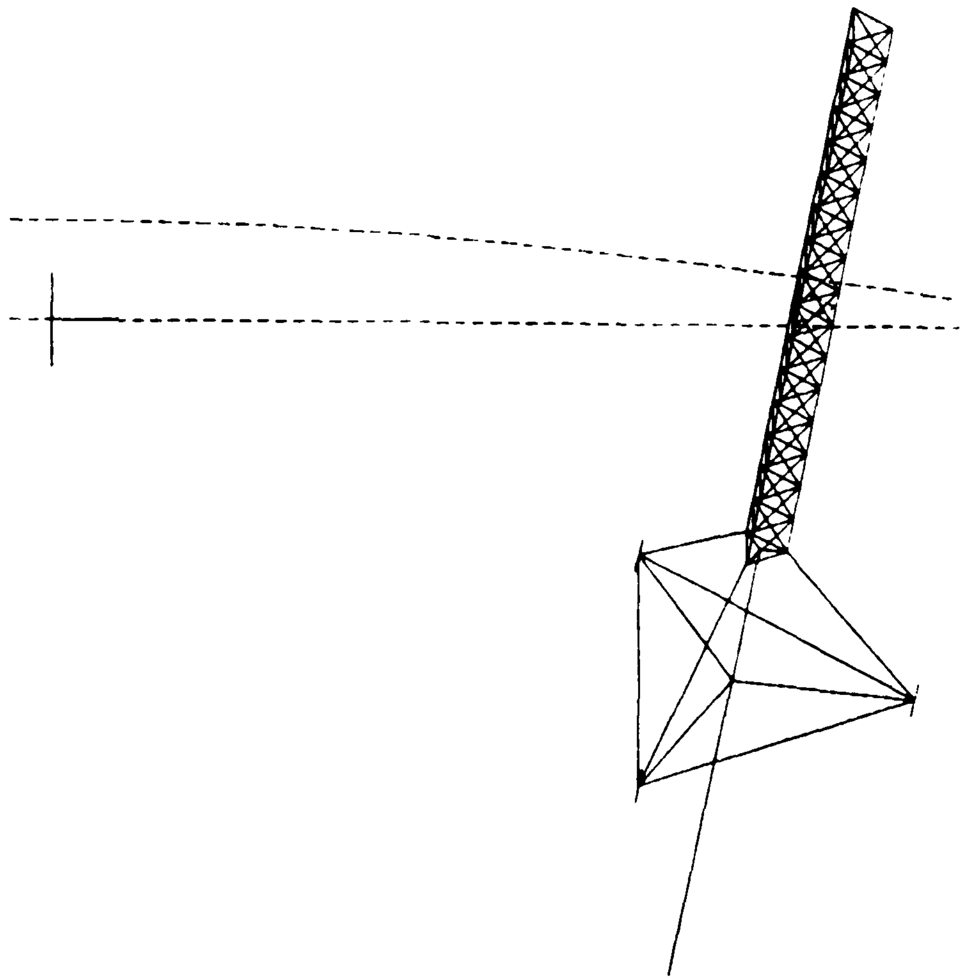


BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 21.76



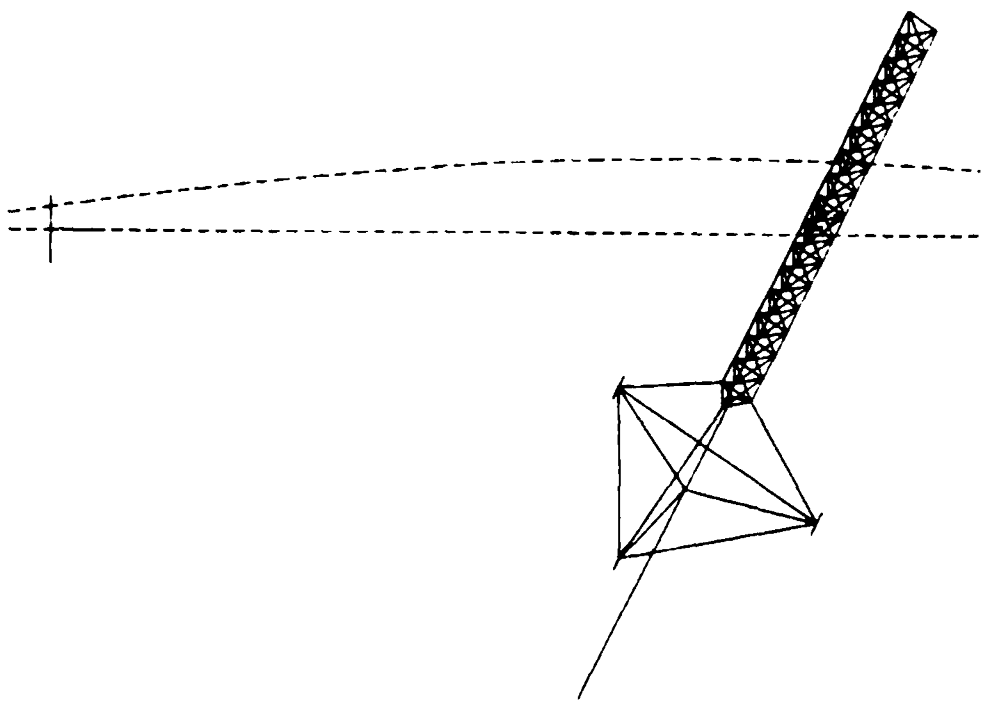
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1   AT TIME =  24.48

PLOT 10 (PAPER SIZE 7.4 X 8.0)



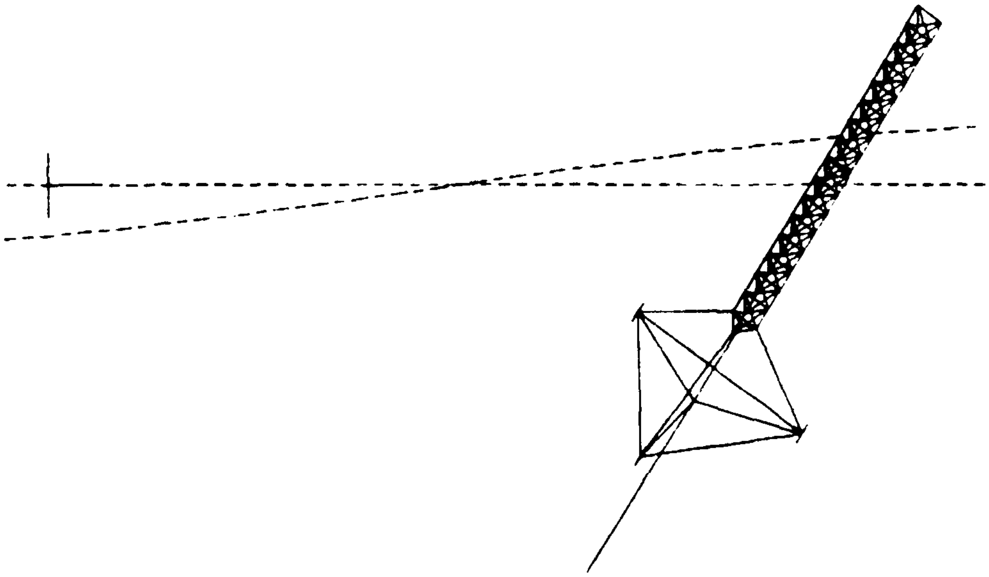
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 27.20

PLOT 11 (PAPER SIZE 7.4 X 7.8)



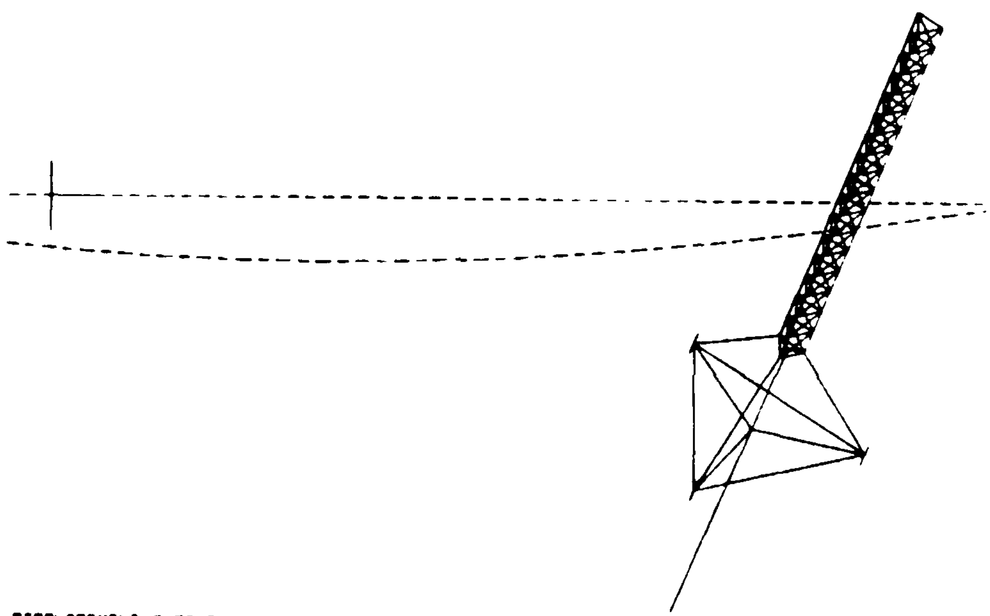
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 29.92

PLOT 12 (PAPER SIZE 7.4 X 10.2)



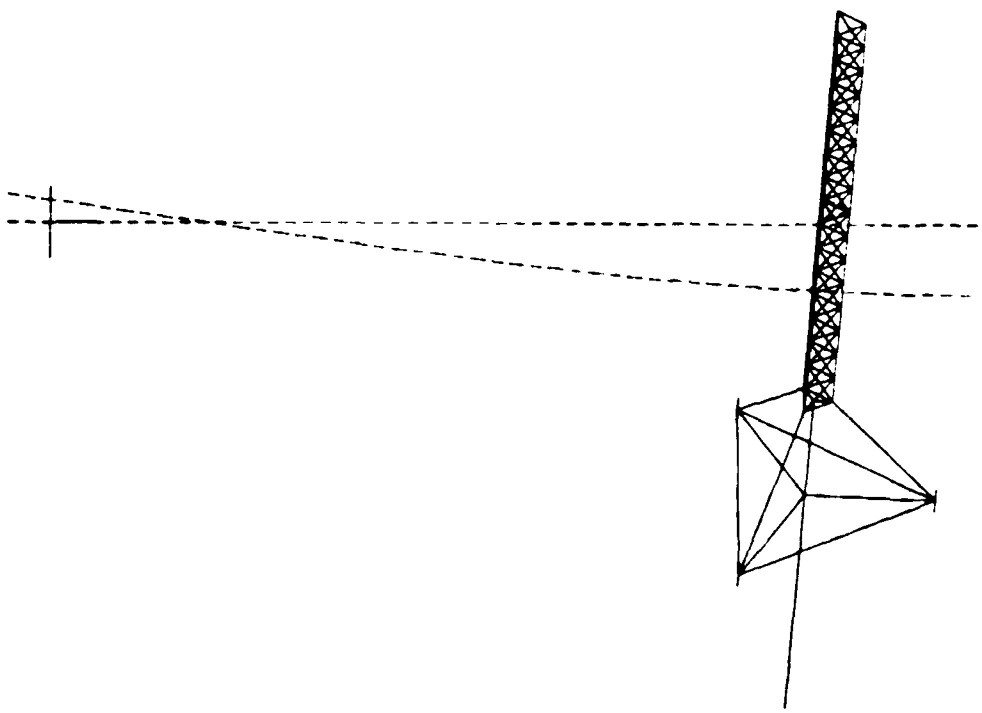
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 32.64

PLOT 13 (PAPER SIZE 7.4 X 12.4)



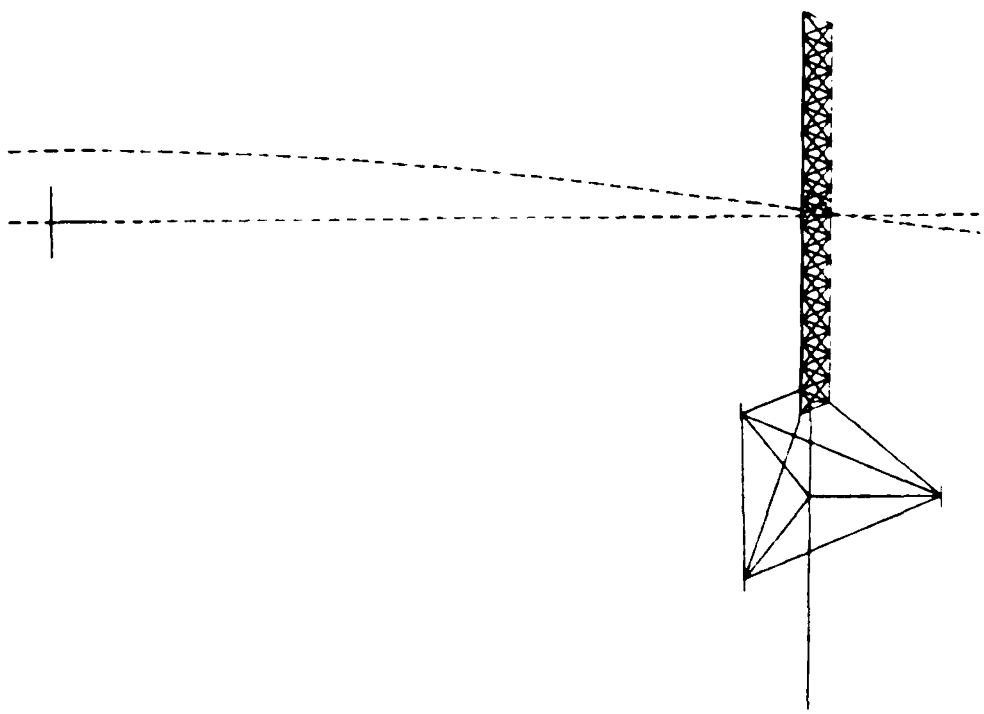
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 35.36

PLOT 14 (PAPER SIZE 7.4 X 11.7)



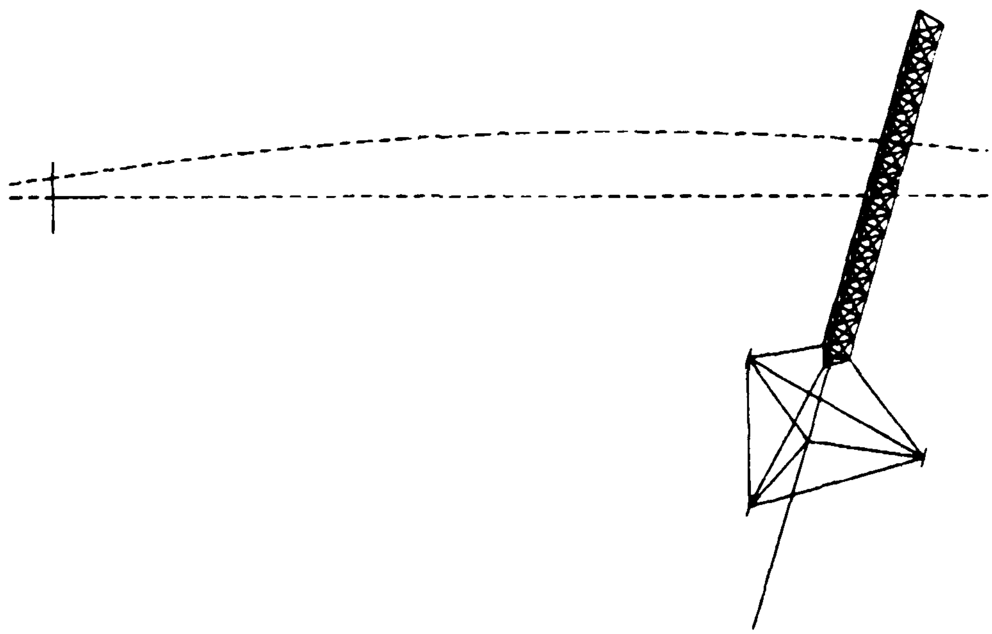
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 30.00

PLOT IS (PAPER SIZE 7.4 X 10.11)



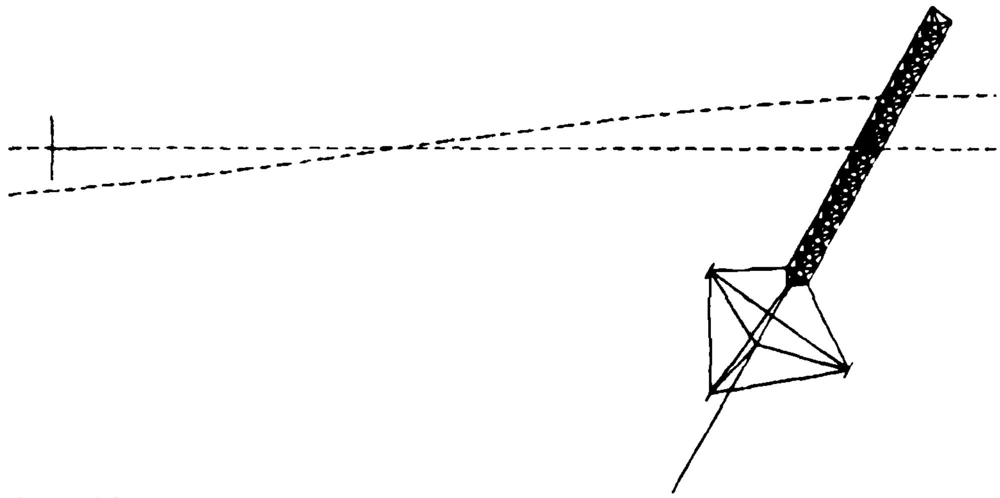
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 40.80

PLOT 10 (PAPER SIZE 7.4 X 10.1)



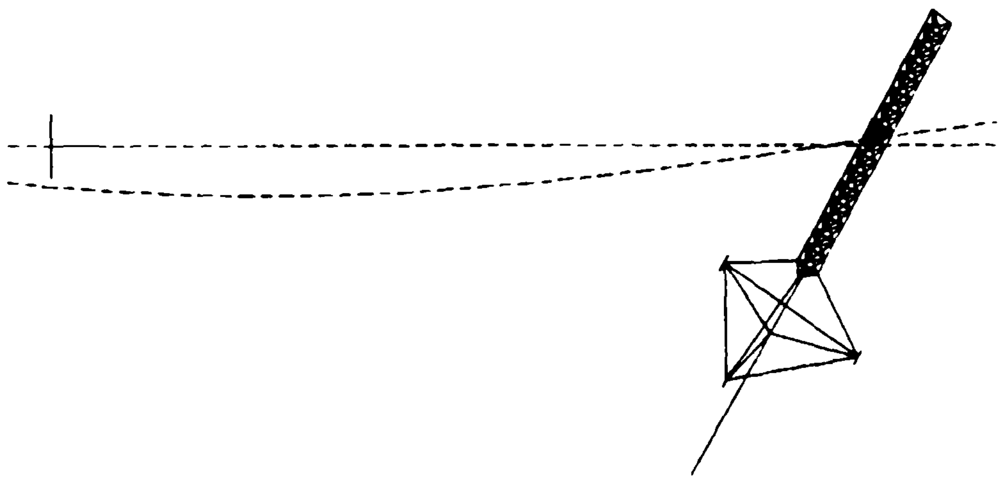
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1   AT TIME =  43.52

PLOT 17 (PAPER SIZE 7.4 X 11.4)



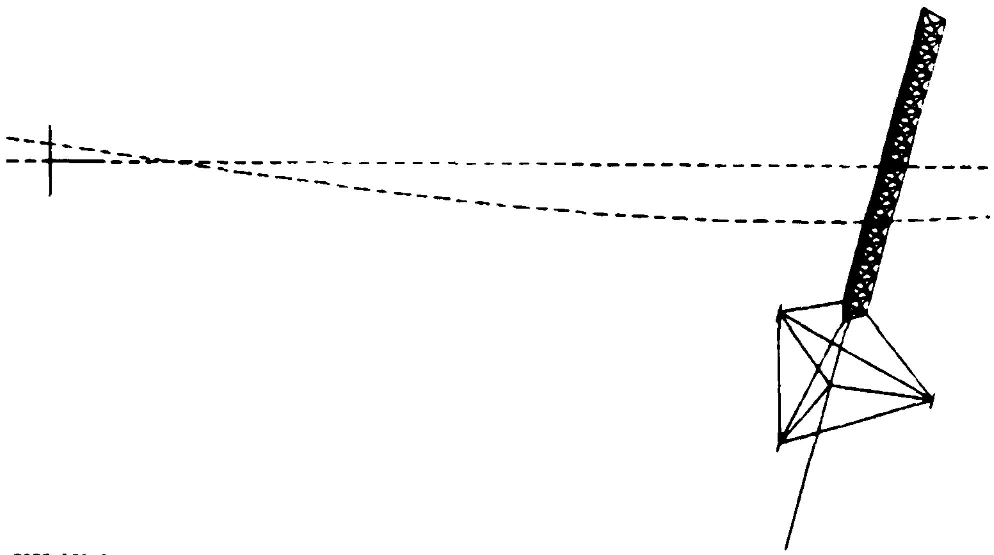
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS:   AT TIME =  46.24

PLOT 10 (PAPER SIZE 7 4 X 14 5)



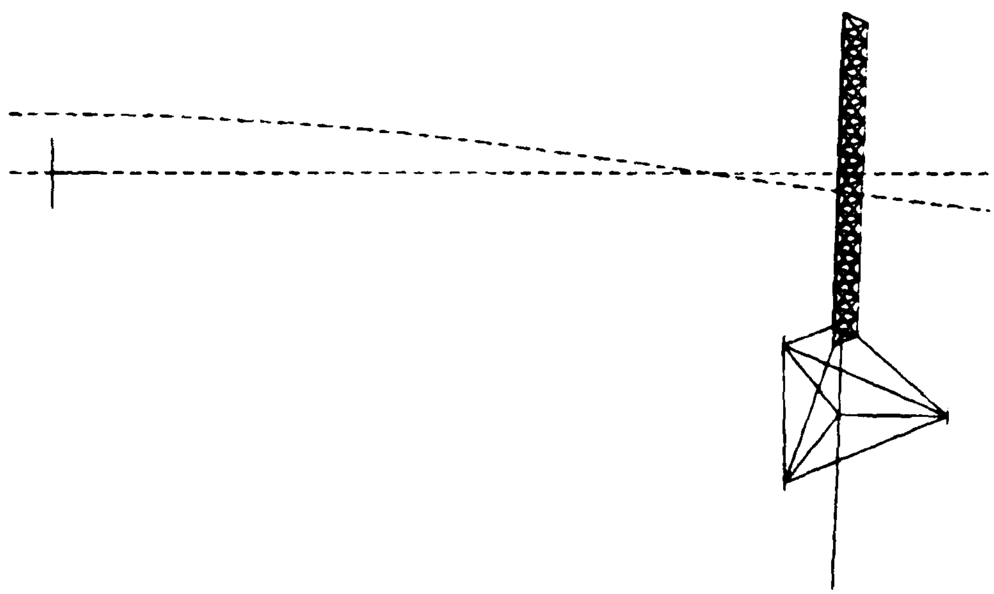
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 48.96

PLOT 18 (PAPER SIZE 7.4 X 15.2)



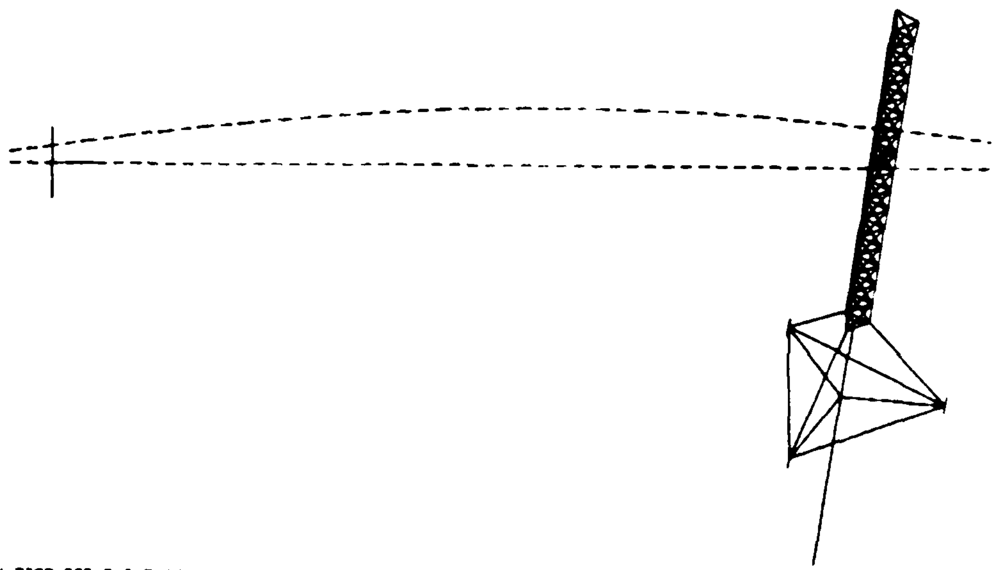
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 51.68

PLOT 28 (PAPER SIZE 7.4 X 13.0)



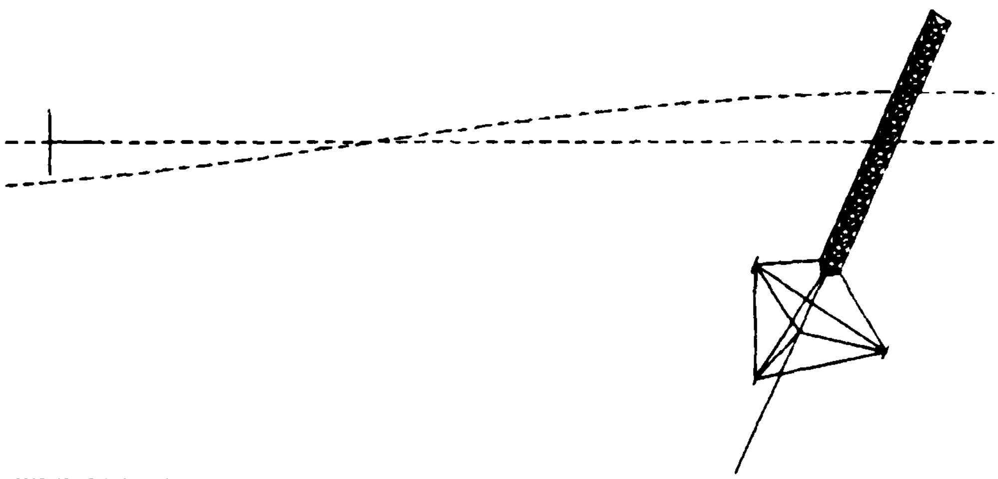
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 54.48

PLOT 21 (PAPER SIZE 7.4 X 12.2)



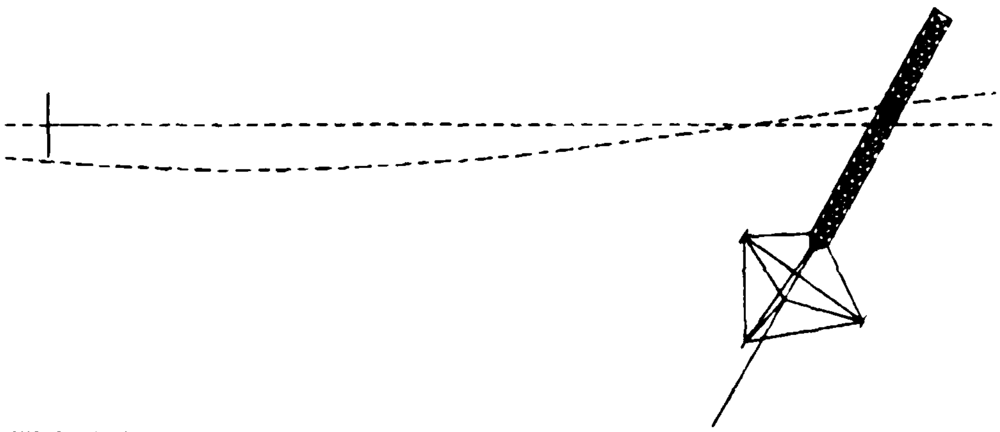
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS! AT TIME = 57.12

PLOT 22 (PAPER SIZE 7.4 X 12.7)



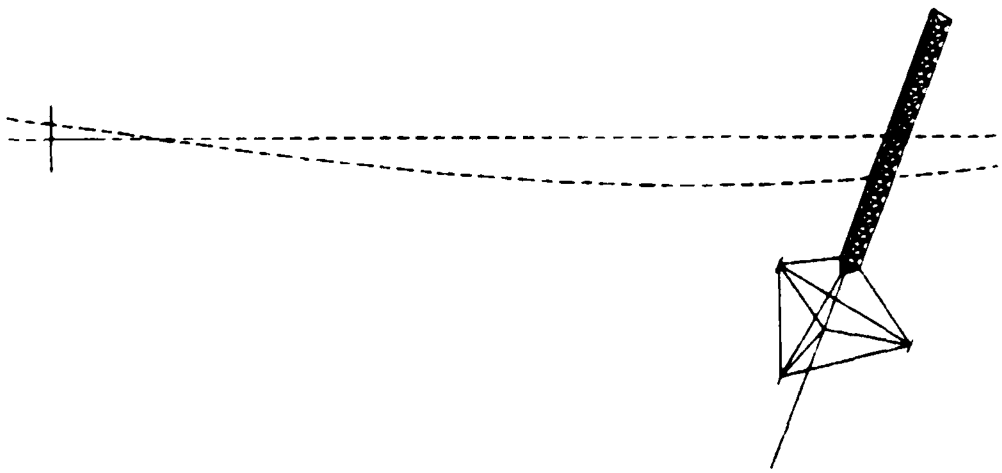
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME = 59.84

PLOT 23 (PAPER SIZE 7.4 X 16.2)



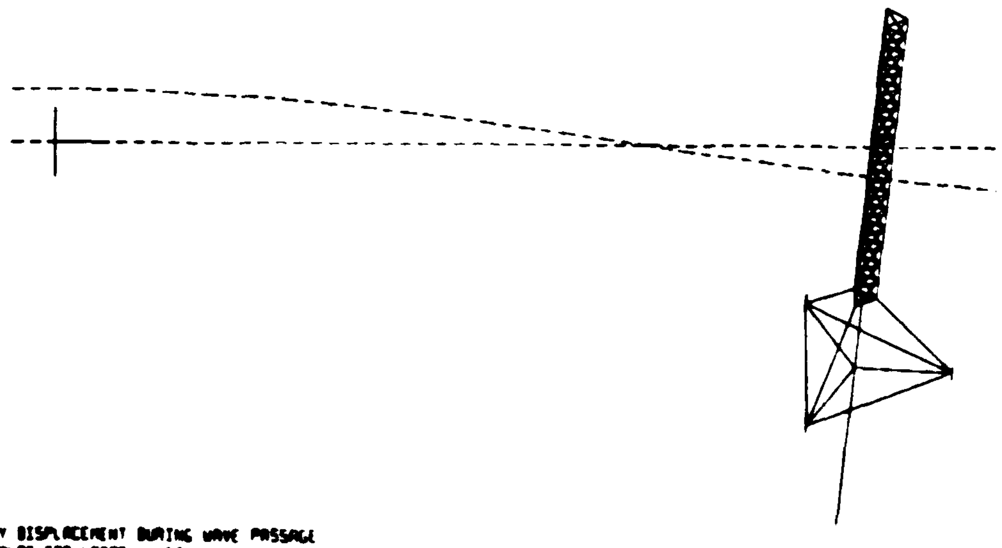
BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1 AT TIME = 62.56

PLOT 24 (PAPER SIZE 7.4 X 10.0)



BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1    AT TIME = 65.28

PLOT 25 (PAPER SIZE  7.4 X  15.3)



BUOY DISPLACEMENT DURING WAVE PASSAGE
3D PLOT FOR LOADS1  AT TIME = 60.00

PLOT 20 (PAPER SIZE 7.4 X 10.0)

END

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